THE EAST MIDLAND GEOGRAPHER

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EDITORIAL NOTE

The costs of publication of the East Midland Geographer have increased substantially since its inception in June, 1954. The Editorial Committee is therefore reluctantly compelled to give notice of an increase in selling price. Beginning with No. 17 (June 1962) the price will be 7s. 6d. a number, post free (annual subscription 15s. 0d.). The price of No. 16 (December 1961) will remain unchanged at 4s. 9d. post free.

The Editorial Committee takes this opportunity of thanking regular subscribers for their continued support, and of expressing gratitude to the many institutions, mainly abroad, that send valuable geographical publications in exchange for this journal.

Many inquiries have been received concerning the grouping of numbers of the East Midland Geographer. It has now been decided that eight numbers shall constitute a volume. Volume 1 will be deemed to consist of Numbers 1 to 8, and Volume 2 of Numbers 9 to 16 inclusive. Volume 3 will begin with No. 17 (June 1962), and thereafter the pages in each volume will be numbered consecutively. In due course it is hoped to produce an index for Volumes 1 and 2.

The Committee regrets that early numbers of this journal are in short supply. A few copies of Nos. 4, 8, 9, 11, 12, 13 and 14 are available at the published price, and a number of sets excluding Nos. 1, 2, 3 and 6 are also available. Eventually it is hoped to reproduce photographically copies of Nos. 1 to 8, which would then be sold at 7s. 6d. a copy.

It is the constant object of the Committee to maintain, and wherever possible, to improve the standard of the East Midland Geographer. It has been decided to make several innovations in future issues, such as a more frequent use of half-tone illustrations and the publication of reviews of books of geographical interest concerning the East Midlands. Any suggestions from subscribers would be welcomed.

IRON AND STEEL AT CORBY.

D. C. D. Pocock.

The mention of 'Corby' brings to mind above all the large iron and steel works which is the *raison d'être* of this new town of 35,000 inhabitants. The plant, which occupies a site of 350 acres adjacent to the line of the former Midland Railway Company on the east side of the town, is already Europe's largest steel tube works, while plans for further expansion have recently been announced. The purpose of this article is to describe some aspects of the location and growth of this important industrial centre.

Timing of Development

The general timing of Corby's development(1) can be related to trends within the British iron and steel industry generally, and also to the growth and policy of the firm of Stewarts and Lloyds(2). Corby began as the last and most northerly of 12 iron works which were established on the Northamptonshire orefield after the discovery, or rediscovery, of the deposits in the 1850's (Fig. 1). These various works were of moderate size and produced forge and foundry pig for the Midlands and South Wales, to which areas also much ore was exported. No steel was made until 1934. The original industrial development took this form on account of a combination of several factors—an inland position, the absence of local coal, the lack of any nearby metal-consuming industries, and the late opening up of the Northamptonshire orefield, at a time when other metallurgical deposits were already well-established. Even after it became possible, towards the end of the nineteenth century, to make steel from iron smelted from phosphoric ores—such as those of Northamptonshire—some prejudice as regards quality remained, and this contributed to the delay in the introduction of steel making in the Corby area(3).

Stewarts and Lloyds, a company formed in 1903 by the merging of the two leading tube-producing firms in Glasgow and Birmingham, was one of several manufacturers to enter the East Midlands in the first part of this century and acquire leases of Northamptonshire ore in order to safeguard future supplies of the raw material. Leases covering 500 million tons of ore were taken up, together with the Corby and Islip ironworks, acquired in 1920 and 1930 respectively. It is perhaps of historical interest to note in passing that the Corby works had earlier been offered to Stewarts and Lloyds, but that they were then rejected and later acquired only incidentally through the purchase of the company—Alfred Hickman's, of Bilston—that had taken over the works in the meantime. Even then, Corby's potentialities as a major iron and steel centre lay unrealised for several years.

In the late 1920's Stewarts and Lloyds initiated a programme of reorganisation of the tube industry, involving a more effective co-ordination of their plants and with a view to producing steel for tube manufacture from home ores. The report of a firm engaged to undertake a general survey recommended that an integrated plant should be established at Corby, where conditions of site and ore reserves were

much superior to those of the former North Lincolnshire Iron Company at Frodingham (Scunthorpe). The latter, including the 23 million tons ore reserves, which had been acquired by Stewarts and Lloyds in 1922, was accordingly sold to the United Steel Companies in 1931.

Although the report was published in February, 1930, work on erecting the new plant did not begin until March, 1933, the delay being caused by the depressed state of the national economy. Thus the timing of the project within this general period may be related more exactly to the £3.3 million loan from the newly formed Bankers' Industrial Development Company and to the 33⅓ per cent duty imposed on steel imports, both in 1932.

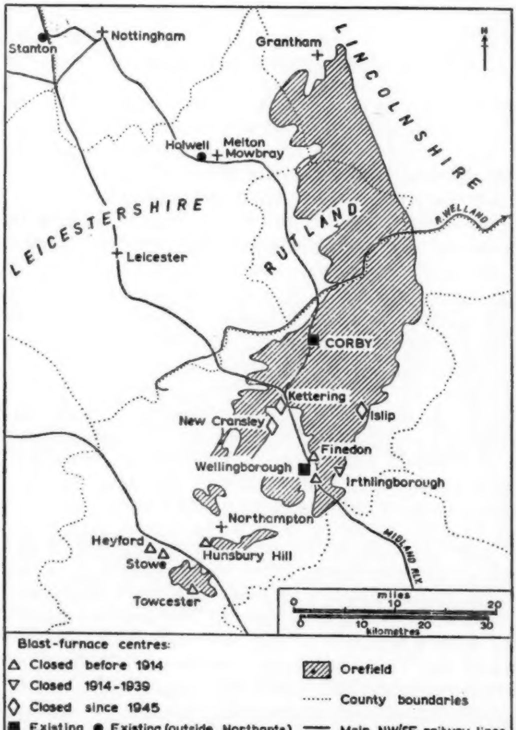

Figure 1
Iron-smelting centres

Discussion of Location

The choice of the detailed location of the large iron and steel plant within the orefield was determined by the geographical coincidence of several favourable factors—the existence of an established works in that portion of the field most suitable for exploitation, on a site capable of extension and adjacent to an important railway line. Some features of both general and detailed location may now be discussed in further detail.

The Northampton Sands orefield, of which Stewarts and Lloyds possess 80,000 acres, was the primary locating factor. This deposit is the richest and most extensive of the three ore-bearing series of Jurassic age in the whole of England(4). Corby is approximately in the centre of the field (Fig. 1), where it happens that the ore can be obtained by open-cast quarrying methods. North of the river Welland, on the other hand, the ore becomes increasingly difficult to recover in this way because of the increasing thickness of the massive Lincolnshire Limestone. This is shown by the estimate of the proportions in the two parts of field that can be extracted by quarrying and mining respectively, and is also reflected in the production figures (Table 1). The recent joint survey by Stewarts and Lloyds and the United Steel Companies of the reserves to the north of the Welland has confirmed the unfavourable extraction conditions of the orefield in Rutland and South Lincolnshire.

TABLE I

ORE RESERVES AND PRODUCTION OF THE NORTHAMPTON SANDS FIELD. ('000 TONS)

Area	*Total Reserves*	*Recoverable by:- Quarrying*	*Mining*	*Production* 1938	1959
North of Welland ..	666,660	190,610	476,050	1,411	2,689
South of Welland ..	560,589	424,249	136,340	3,832	4,830

Sources: *The Northampton Sands Ironstone: Stratigraphy, Structure and Reserves*, H.M.S.O., (1951), p. 74 ; Iron and Steel Board and British Iron and Steel Federation, *Iron and Steel: Annual Statistics for the United Kingdom, 1959* (1960), Tables 3 and 4.

Secondly, Corby's location within the orefield is advantageous in that it is in the area where the ore-bed is continuous, whereas a few miles to the south the deposit has been strongly fragmented by stream dissection. It is no coincidence, therefore, that the concentration of both ore extraction and iron moved from the early workings of the southern, discontinuous section of the field northwards towards the centre of the field.

Iron ore is therefore available in large quantities. Moreover, the siliceous nature of the ore results in pig with good welding qualities highly suited for steel tube production. The ores are 'lean', with an iron content averaging only 30-33 per cent., but they can be extracted by open-cast methods, with a labour force only one-tenth of that which would be necessary for an equivalent output of mined ore. Some five million tons a year are excavated by only 700 out of a total labour force of nearly 11,000 employed by Stewarts and Lloyds. This reflects not only the physical nature of the beds—a band of 8-10 feet in thickness beneath an overburden of 20-25 feet in the Corby area—but also the degree and scale of mechanisation. Corby has always benefited by being in the forefront of mechanised ore-quarrying ever since the introduction into the Corby pits of the orefield's first mechanical excavator, the 'steam navvy', in 1895. Before that date the ore had to be won by pick and shovel, based on the 'plank and barrow' method, which restricted working to areas with less than 15-20 feet overburden. In the 1930's

Corby had the first electric excavator, which made it economic to remove up to 55 feet overburden, while the 1950's saw the introduction of 'walking draglines'. The two largest of these, in quarries at Prior's Hall and Cowthick, can work up to 100 feet overburden and produce 400,000 tons of ironstone each in one year.

Maximum advantage is taken of the proximity of the ironstone pits to the blast furnaces, as the company possesses its own track, engines and rolling stock. Transport costs to one distant quarry at Rothwell have been reduced by the construction of a seven-mile aerial ropeway. As a result, the Corby area produces nearly one-third of the output from the Northampton Sands orefield, or one-sixth of the total national output of iron ore. Some 2½ million tons a year are fed directly into the Corby blast furnaces.

Although Corby is distant from coal this is now less of a disadvantage than formerly, for progressive technical improvements have reduced the ratio of 'coal equivalent' to ore used in blast furnaces to 3 :5, so that it is cheaper to transport coal to the orefield than ore to a coalfield site, assuming that transport charges are the same per ton-mile for ore and coal. The main sources of coal are the North Derbyshire and South Yorkshire fields, to which Northamptonshire ore is itself despatched along the lines of the former Midland Railway for blast-furnaces in these areas.

Of the remaining raw materials, foundry sand is brought from the Mansfield area of Nottinghamshire, and limestone for fluxing is obtained locally. Adequate water supplies, however, were initially a problem. In 1929 Corby's ironworks, relying on local wells and water from excavation hollows of former brick workings, were in danger of being closed through insufficient water supplies. The requirements of the modern works have only been met by the construction of the Eyebrook reservoir on the borders of Leicestershire and Rutland between 1937 and 1940, and by its enlargement in 1955, when also the source of domestic supply for the town was transferred to the Pitsford reservoir. The present net daily consumption of six million gallons by the works is supplemented by Blatherwycke Lake and Thrapston gravel pits. Labour also has been a difficult problem, for the first 2,000 employees and their families were all transferred by the firm from existing works in the Glasgow and Birmingham areas and from South Wales. Moreover, the local area has been unable to supplement this labour nucleus, and the company has thus been forced to transfer further workers to Corby and carry out nation-wide recruitment compaigns in conjunction with the Ministry of Labour(5). Before it was relieved by the local Urban District Council the company also erected some 2,100 houses and provided other amenities in Corby. Clearly labour, although not a dominant locating factor, has been a costly item.

The relative importance of market is difficult to assess. Corby is the nearest steel producer to London and is centrally located between the Birmingham and London areas, where one-third of the country's steel is consumed. Although this was an advantageous factor, mentioned in the 1930's(6), it must be borne in mind that about one-half of Corby's production is, in fact, for the export market.

From the production point of view, it is the ease of ore extraction, the integration of blast furnaces, steel converters, rolling and tube mills, together with the favourable fuel-ore ratio, which makes Corby the cheapest location in the country for steel production. The minimum cost advantage over other plants has been estimated at five shillings per ton of pig iron(7). The advantages of integrating tube manufacture with steel production means that of the final prime cost of tubes four-fifths is that of the steel and only one-fifth its conversion into finished tubes. Plausible arguments have been put forward that there should be a large scale movement of the British steel industry to the orefields of the East Midlands(8).

Growth of Production

The growth of the iron and steel industry at Corby may be illustrated by particulars of plant extension, output, numbers employed and growth of the town in selected years (Table 2).

TABLE 2

EXPANSION OF THE CORBY WORKS

Year	*Blast Furnaces*	*Steel Converters*	*Production (tons) Pig Iron*	*Steel*	*Company Employees*	*Town Population*
1914	2	—	50,000	—	650	1,350
1939	4	3	565,000	498,500	3,950	10,880
1950	4	7	650,000	724,500	7,750	15,700
1960	4	9	895,000	1,147,500	10,700	35,000
Future	5	10	1,350,000	1,550,000	14,000	80,000

Sources: *Review of Stewarts and Lloyds, Ltd., 1903-1953,* (1953); *Corby Works,* (1952); *Reports of Annual General Meetings* of Stewarts and Lloyds, Ltd.

Although quarrying began in the Corby area in 1882, soon after the completion (1880) by the Midland Railway of an alternative line between Kettering and Nottingham(9), it was almost 30 years before Lloyds Ironstone Company erected the first blast furnaces to utilise the local ore. Work began in 1908, and the first two furnaces were lit in 1910 and 1911, while a third was added in 1918 during the wartime boom. The furnaces were the largest on the orefield, with a total annual capacity of 50,000 tons of pig. Basic pig, largely for the metallurgical industries in the West Midlands, remained the plant's objective until the early 1930's, for the acquisition by Stewarts and Lloyds in 1920 had no immediate effect.

The second phase began with the production of the first steel at the end of 1934. During a period of three years the three blast furnaces were reconstructed, and three basic Bessemer converters were installed as part of a broad plan to produce 400,000 tons of pig iron, yielding 300,000 tons of semi-finished steel for processing in new rolling and tube mills. The scheme, which was announced cautiously during the depression and which appeared ambitious, even courageous, was, in fact, considered too modest within a few years(10), and a fourth blast furnace was added in 1937. By 1939 production of pig had exceeded half a million tons.

The immediate post-war period did not bring continued large scale expansion, in view of the 1946 five-year modernisation plan of the British Iron and Steel Federation, which recommended that a second integrated plant of 500,000 tons capacity should be established on the Northamptonshire field([11]). The plan, however, did not materialise, and the additional capacity was installed at Corby, thus initiating the third phase of expansion, an expansion which induced the government to place the now sizeable urban settlement under the direction of a New Town Development Corporation. The new plant, in addition to two further basic Bessmer converters, also included two basic open-hearth and two electric steel furnaces([12]), which meant that steel production was now no longer exclusively by the basic Bessemer method (Table 3). Although this process is technically more efficient in treating iron made from Northamptonshire ore, the five Bessemer converters were unable to absorb scrap in any quantity. The open hearth, and to a lesser extent the electric furnaces, were therefore introduced to make use of the considerable amount of scrap that always arises during the various rolling and finishing stages of steel making([13]).

TABLE 3

TYPES OF STEEL PRODUCED AT CORBY. ('000 TONS)

Year	*Basic Bessemer*	*Basic Open Hearth*	*Electric*
1935	223.8	—	—
1950	556.1	124.6	43.6
1960	834	250.2	63.3

Source: *Statistical Yearbooks* of British Iron and Steel Federation.

Yet another phase of expansion at Corby has recently been announced (January, 1961) ([14]). This follows on the disappointing findings of a recent survey of the extent, nature and workability of the unproved reserves of that part of the Northampton Sands orefield lying to the north of the river Welland. This study was undertaken jointly by Stewarts and Lloyds and the United Steel Companies at the request of the Iron and Steel Board, the government body which exercises broad supervision over the steel industry and its development. It was found that over the greater part of the area the ironstone would be uneconomic to work. Since the Board was already in favour of an expansion of steel-making capacity on the Northampton Sands field it was therefore decided that this should take the form of further growth at Corby rather than of a new plant to the north. The increased future demand for iron ore at Corby will obviously mean a greater rate of extraction locally. Corby's iron and steel capacities will be raised by 450,000 tons, with consequent increases also in the steel rolling and tube making facilities. A fifth blast furnace is to be erected, and also additional ingot reheating furnaces. This latest scheme, which will cost £35 million and be spread over four years, will also enable further economies in the cost of iron and steel making at Corby.

Corby in Perspective

In conclusion, Corby's production may be seen in relation to the total output of Stewarts and Lloyds and to figures for the United Kingdom (Table 4). In 1959 Stewarts and Lloyds produced nearly 4½ million tons, or about 30 per cent., of the country's home iron ore,

TABLE 4

PRODUCTION AT CORBY IN RELATION TO TOTAL STEWARTS AND LLOYDS AND NATIONAL OUTPUTS ('000 TONS)

	Year	*Corby*	*Total S. & L.*	*U.K.*
Home-produced Iron Ore	1938	1,700	2,600	11,860
	1959	2,500	4,400	14,870
Pig Iron	1938	500	1,100	6,760
	1959	850	1,700	12,580
Crude Steel	1938	430	675	10,400
	1959	1,010	1,415	20,180
Steel Tubes	1938	210	420	665[1]
	1959	450	865	1,161[2]

Sources: Iron and Steel Board and British Iron and Steel Federation, *Iron and Steel: Annual Statistics for the United Kingdom, 1959,* (1960), Tables 1 and 59.

Stewarts and Lloyds, Ltd., *Employees Reports.*

[1] Incl. tubes of over 16″ diameter.

[2] Excl. tubes of over 16″ diameter.

while the Corby area alone produced 2½ million tons, or about 17 per cent. of the national total. The favourable nature of the ore-beds and the large scale excavation methods have been described above. In the same year Corby produced over six per cent. of the pig iron and five per cent. of the steel made in this country. The 1959 pig-iron production of 850,000 tons now dwarfs the 50,000 tons capacity of the 1911 works or even the 400,000 tons of the 1934 plant. Corby, however, is only one of the five blast-furnace centres of Stewarts and Lloyds, so that its relative importance in total company iron-smelting is lower than for steel-making. The company's other centres are at Bilston (near Wolverhampton), Stanton (near Nottingham), Holwell (near Melton Mowbray) and Wellingborough. Wellingborough is the only other blast-furnace centre located on the Northamptonshire field, for Stewarts and Lloyds have recently closed the Islip (1949), New Cransley (1958) and Kettering (1959) iron-works through increasing obsolescence and/or poor detailed location (Fig. 1). The overall loss to company production has been more than offset by the increased capacity of the Corby works. All Corby's pig-iron production is fed directly into the steel converters.

Over 70 per cent. of the company's steel was produced at Corby in 1959, the remainder coming from Bilston and Mossend, Lanarkshire. One-tenth of Corby's production is despatched to other tube works in the West Midlands, Wales and even Scotland, but the bulk of the steel

is retained for tube production at Corby, and it is in this branch, of course, that Corby is of national significance([15]). Tubes, which range from a quarter to $5\frac{1}{2}$ inches in diameter, are produced in three separate plants according to quality of steel and type of product required: four continuous weld mills (550,000 tons annual capacity) and one electric resistance weld mill (60,000 tons capacity) utilise steel strip, the latter mill using the open hearth steel, while one plug mill (55,000 tons capacity) produces seamless tubes from steel bars. In 1960, when the company's eight tube works produced 1,006,000 tons of steel tube, Corby's contribution was some 600,000 tons. It is therefore by far the largest single steel tube making unit in the country, annually producing one-third of the national total, or sufficient tubing to girdle the earth three times round. Moreover, company policy and the economic advantages inherent in Corby's location, which have been described above, will ensure that its output and relative importance will continue to increase in the future.

NOTES

(1) For a detailed account of the development of the Northamptonshire iron industry see S. H. Beaver, The iron industry of Northamptonshire, Rutland and South Lincolnshire, *Geography* 17 (1933) 102-117, and Idem, The development of the Northamptonshire iron industry 1851-1930, in *London Essays in Geography* (ed. L. D. Stamp and S. W. Wooldridge), (1951) 33-58.

(2) *Review of Stewarts and Lloyds, Ltd. 1903-1953* (1953).

(3) D. L. Burn, *The Economic History of Steelmaking 1867-1939*, (1940) pp. 172-182

(4) *The Northampton Sands Ironstone: Stratigraphy, Structure and Reserves*, H.M.S.O., (1951).

(5) D. C. D. Pocock, Migration of Scottish labour to Corby New Town, *Scottish Geographical Magazine* 76 (1960) 169-171 and Idem, Some features of the population of Corby New Town, *The Sociological Review*, 8 (1960) 209-221.

(6) *The Times*, 30th November, 1932.

(7) H. G. Roepke, Movements of the British iron and steel industry, 1720-1951, *Illinois Studies in the Social Sciences*, 36 (1956) p. 165.

(8) D. L. Burn, op cit. For a criticism of these views see P. S. Andrews and E. Brunner, *Capital Development in Steel* (1951) pp. 97-98.

(9) C. E. Stretton, *History of the Midland Railway* (1901) pp. 223-224.

(10) *The Times*, 2nd May, 1934.

(11) *Iron and Steel Industry*. Reports by the British Iron and Steel Federation and the joint Iron Council to the Minister of Supply, Cmd. 681, H.M.S.O. (1946) pp. 22-23.

(12) *Review of Stewarts and Lloyds, Ltd. 1903-1953*, (1953), pp. 90-93. See also *Corby Works*, (1952), and "Corby's iron and steel works", *The Engineer*, 160 (1935), 449-51, 474-75, 509-10, 539-40.

(13) Although no open hearth furnaces were erected until 1949 their desirability was recognised from the outset. *The Times*, 2nd May 1934.

(14) A. G. Stewart, Company and Annual General Meetings, reported respectively in *The Times*, 13th January 1961 and 9th February 1961.

(15) D. C. D. Pocock, British steel tube production, *Geography* 45 (1960) 290-291.

THE HUMBER FERRIES AND THE RISE OF NEW HOLLAND, 1800-1860.

A. Harris

The only ferry service that operates across the river Humber at the present time links Kingston-upon-Hull with the village and railway terminus of New Holland in Lincolnshire (Fig. 1). Unlike most of the former Humber ferries this is a relatively recent creation whose origins go back no further than the first half of the nineteenth century. Immediately after its establishment the new ferry came into competition with other ferry services across the river, some of which had been in operation since the fourteenth century. Eventually these fell into disuse and traffic across the Humber became confined to the route between New Holland and Hull.

The new line of communication had a profound effect on an outlying part of the parish of Barrow upon Humber, where a village grew up close to the ferry terminus on Humberside. In a district of ancient settlements of agricultural origin New Holland stands apart, the creation of an age of new and improved methods of communication. The village, which extends for about half a mile along both sides of the main approach road to the ferry terminus, and contains about 1200 inhabitants, consists of little more than two rather irregular lines of buildings, many of which date from the second half of the nineteenth century (Fig. 2). A ferry service is maintained by steam paddle boats between Hull and New Holland, where connections by rail and road are available to various parts of north Lincolnshire. At one time the ferry, road and rail services provided a livelihood for most of the villagers, but this is not the case to-day. These services, and the local brickmaking and shipbuilding industries employ only a small proportion of the working population, and many travel daily to work in Immingham, Scunthorpe and elsewhere. The growth of the village and the ferry service which led to its development are traced below.

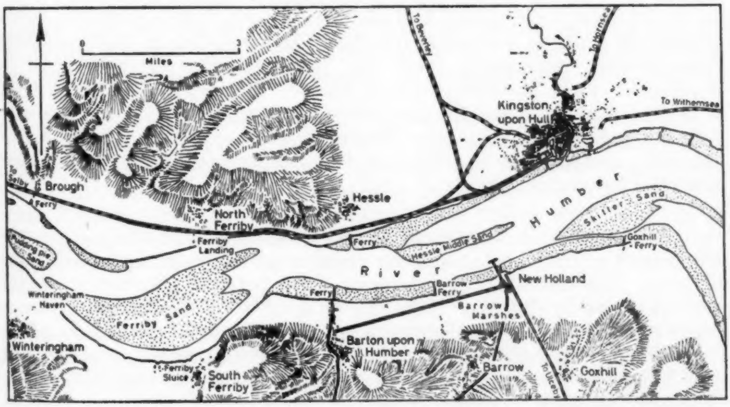

Figure 1—The River Humber in the vicinity of Hull
Based on a reprint of the Ordnance Survey One-Inch map of 1824, on which railways and certain other features are shown to the date of publication in 1876.

In the early years of the nineteenth century passengers and goods were carried across the Humber from a number of points on the Lincolnshire coast. From small creeks and havens such as Stallingborough, Goxhill, Barrow and Winteringham, market boats made regular journeys to Hull with local villagers and agricultural produce(1). Some of the boats crossed the river twice a week to catch the Tuesday and Friday markets in the town, but many sailed only once a week or once a fortnight. They were sufficiently numerous to give rise to the belief that there was not a village on Humberside without a market boat and to cause appreciable congestion at Hull, both in the Old Harbour and along the Humber waterfront(2).

Although numerous, the market boats played only a limited part in the regional system of communications, for their sailings were too infrequent to attract other than local travellers, and more frequent passages were actively discouraged by the owners of the ancient ferries who were prepared if necessary to resort to legal action to restrict competition from the market boats(3). Of much greater importance, therefore, in maintaining day to day links between Lincolnshire and Yorkshire were these ferries: though few in number and subject to considerable delay, they provided the only regular public service across the river.

The shortest crossings were from Winteringham Haven to Brough and from Barton to Hessle; but in the early nineteenth century these routes were less frequented than the one between Barton and Hull, where the direct journey to Hull and the availability of coach connections for those who wished to travel beyond Humberside, compensated for the disadvantage of a longer crossing. Even so, the Barton ferry had a bad reputation. The journey of five miles between Barton Waterside and Hull was frequently prolonged by adverse winds and tides and occasionally proved a hazardous undertaking(4). "The accommodation of the [Barton] Ferry is so bad and dangerous", it was said early in the nineteenth century, that some travellers from London to Hull preferred "the general roundabout road by York" to the shorter route by Barton(5). Little had changed since Defoe's time when the Barton ferry was described as "an ill-favoured dangerous passage". After enduring one unpleasant journey from Barton to Hull of about four hours' duration, Defoe chose on another occasion to avoid the ferry and instead travelled by way of York(6).

A considerable improvement took place in 1821 with the introduction of a steam packet and the erection of better landing facilities at Barton. The number of journeys daily between Barton and Hull was increased at this time from one to two(7). The change to steam appears to have met with general approval in Hull, where it was said to have "materially benefited" the town by making communication with London more direct and much more reliable than it had been hitherto(8). The London mails were subsequently transferred to this route and thus reached Hull by way of Barton instead of York. The Barton steam packet had been in service only a year or two, however, when a competitor appeared.

The ferry service via New Holland developed from very humble origins. According to an account written in 1848, the first ferry service was begun by one Dent soon after 1803. Dent occupied land belonging to the churchwardens of Barrow in the newly enclosed Oxmarsh of that parish([9]). Here, close to the outlet of a main drain, which formed "a sort of creek or haven", Dent built a shed and cottage and with the help of a companion ferried passengers across the Humber in an open boat. The creek also appears to have been used for less innocent purposes, for several nineteenth-century accounts contain references to smuggling there. A writer in the *Lincoln, Rutland and Stamford Mercury* in December, 1848, after describing Dent's enterprise, goes on to relate that: "This primitive state of things lasted for some time, when the convenience of landing afforded by the creek, the isolated position of the spot, the paucity of inhabitants, with other collateral advantages, pointed it out as an eligible place for the debarkation of smuggled goods, but more especially of Hollands gin, and it was notoriously used as such: hence it obtained the name of New Holland."([10]).

Even if it survived, Dent's venture can scarcely have had much effect either on the established ferry services or on the market boats at the nearby haven of Barrow. But in 1825 the Corporation of Hull, owners of the ferry from Hull to Barton and lessees of the Crown ferry from Barton to Hull, were disturbed to learn that a new ferry service was under consideration([11]). The Corporation were informed that a company intended "to establish a daily Passage or Ferry from Barrow to Hull", and to run coaches to London in opposition to those from Barton Waterside, which were run in association with the Barton boats.

The Corporation's information was correct, although their worst fears about its implications were not realised at this time. A local man, Joseph Brown of Barton, purchased land near the Oxmarsh Creek in Barrow, "and in conjunction with a number of influential gentlemen" formed a company to exploit the short crossing to Hull from this point([12]). The company—usually referred to by contemporaries as the New Holland Proprietors—introduced a small boat in 1825 or 1826, and in 1826, for the convenience of their customers, built an inn, the Yarborough Arms, named after a prominent local landowner. This was the first, and for many years the only, public building in New Holland.

The proprietors met with only limited success. It was claimed in 1846 that they did no more than run "an occasional passage . . . to Hull Market"; but one who knew the ferry well in the 1820s asserted that there was a daily service by sailing boat from 1828 onwards([13]). It is clear, however, that plans to introduce a steam packet were deferred, as was the coach service, which had to await the improvement of the very poor road approaches to the shore.

On 11 February, 1832, James Acland, a man of radical opinions, and well known locally for a vigorous political campaign against Hull Corporation, noted in his *Portfolio* that "measures are in embryo for the establishment of a Ferry between Hull and New Holland, together with a coach-line thence to the Metropolis daily". Acland was at this time attempting to disturb the Corporation and their lessees in the occupation of the Barton ferry and had only recently ceased to run a rival steam packet between Hull and Barton([14]). Although the revival of the

New Holland scheme of 1825 had Acland's support and undoubtedly gained strength from his efforts to rouse public opinion against the fares charged on the Barton route, it was not he who implemented it. Some of the original New Holland proprietors, strengthened by new capital and new blood, proceeded with the plan for a regular steam ferry and by the autumn of 1832 a small steam boat, the *Magna Charta,* was running three times daily in each direction between New Holland and Hull, with an extra trip on market days([15]). Not long after the introduction of the passenger service a daily horse boat was brought into use for livestock. The use of a steam packet required better landing facilities at New Holland, and the first of several major schemes to project a jetty across the mud flats that fringe the shore at low water was carried out at this time([16]).

Considerable changes followed the establishment of the new ferry. In 1836, after a period of fierce competition between the rival coach proprietors, the London mail was finally transferred from the Barton to the New Holland route, an event to which the New Holland proprietors had looked forward hopefully for several years and for which they had worked assiduously([17]). The packet, which was run at fairly frequent intervals and achieved a very much more rapid crossing than the Barton boat, attracted passengers at the expense of the ferries at Barton and the passages from nearby creeks, where the market-boat services now began slowly to fall into disuse. The receipts of the Barton ferry, already affected by Acland's short-lived opposition, continued to decline([18]). The growth of traffic at New Holland, by contrast, was so great that by 1846 it was claimed that 70,,000 passengers, two mail and two other regular coach services as well as a number of other vehicles passed through the little settlement each year([19]). With some justice it was said that New Holland had become a "place of great thoroughfare."([20]).

As early as 1832 land in this part of Barrow parish was described as forming part of an improving estate "in consequence of the establishment of the . . . ferry"([21]). About this time the road to the landing-place from the south was improved to attract an increased volume of traffic, and a house for the ferry superintendent was built near the shore([22]). Accommodation at the inn was extended and tea gardens, a bowling green and a skittle ground were added([23]). It was presumably on the strength of these amenities that a writer in the *Hull Advertiser* suggested in 1833 that New Holland was "becoming a fairy land"([24]). In that year the settlement consisted only of the inn and one or two other buildings near the shore([25]).

Directories confirm that further growth took place before the coming of the railway, but early in 1848 New Holland still comprised only "a few cottages and a way-side inn"([26]). There was indeed little to attract a large resident population. Most visitors passed straight through, or at most spent a short time there whilst waiting for boat or coach. The ferry was timed to meet coach services, so it was not even necessary to provide extensive overnight accommodation at the terminus on Humberside. Other visitors to New Holland were mostly day trippers from Hull who came over during the summer months. Some of these persons no doubt patronised the Yarborough Arms and its pleasure gardens, but they required little in the way of local services([27]). All this changed with the arrival of the railway.

"It is the Manchester, Sheffield and Lincolnshire Railway which has caused the erection of the Village of New Holland", observed a writer in 1856([28]), by which time the settlement was sufficiently important to be given a section of its own in local directories and was widely known for its railway and ferry works. The Manchester, Sheffield and Lincolnshire railway acquired the New Holland ferry through a constituent company, the Great Grimsby and Sheffield Junction Railway Company, whose directors had purchased it for the sum of £10,000 in 1845([29]). New Holland was chosen by the Great Grimsby and Sheffield Junction promoters to be the terminus of a branch line from their main line between Grimsby and Gainsborough. In 1846 this company amalgamated with others to form the Manchester, Sheffield and Lincolnshire Railway, and the scheme to develop the Humber ferries in association with these railways was pursued by the new company.

The opening of the New Holland branch to traffic on 1 March, 1848, was quickly followed by changes in the little settlement at the end of the line. By the close of the year a station had been erected; a new pier with rail access along its length was in use though still incomplete; a small dock was under construction and an improved ferry service in operation([30]). Nineteen houses had been built "in addition to those already built for the workpeople at the station"([31]). By 1850 the long pier giving access to deep water was provided with a floating landing-stage to permit its use at all states of the tide; and warehouses, cattle sheds and coal wharves had appeared by the side of the new dock. A timber pond adjoined the dock([32]). In the summer of 1850 the first timber ships to use New Holland were unloaded there, a sure sign, according to one local enthusiast, that the little creek was "on the eve of becoming" a port([33]). The railway company was in fact hopeful that general cargoes might follow the timber and was seeking a customs arrangement at this time.

After 1848 New Holland grew rapidly. "Besides the company's houses, private individuals are building terraces", it was reported in October, 1850, "which are no sooner erected than tenants are immediately obtained, so that cottage-building here seems to be a profitable

TABLE 1
THE INDUSTRIAL AND OCCUPATIONAL STRUCTURE OF NEW HOLLAND IN 1851
(Males 16 years of age and over)

Employed on the railways (drivers, firemen, guards, porters, etc.)	*Employed on the river and on the docks (watermen, coastguards, dock labourers, etc.)*	*Employed in agriculture (farmers and agricultural labourers)*	*Employed in brickmaking*	*Others (masons, bricklayers, butchers, shopkeepers, etc.)*
75	24	9	5	29

Source: Enumeration returns 1851, parish of Barrow upon Humber.
N.B. The totals must be regarded as approximate. Doubtful cases are included in the category "Others", and it is likely that this group is rather larger than it was in reality.

speculation"[34]. A Church of England school-chapel, a Wesleyan chapel, a new Yarborough Arms in the place of the old, which was demolished during the construction of the railway works, and a number of public houses and beershops had appeared by 1856[35].

New Holland is mentioned in the published census returns of 1851 only in passing, as a part of the parish of Barrow, where a rapid growth of population had occurred within recent years[36]. No separate figures are given and it is therefore impossible from this source to determine the size of the village. Fortunately the unpublished census papers fill the gap and provide in addition a detailed picture of New Holland in the spring of 1851[37].

In March of that year the village contained seventy-four inhabited houses, six empty dwellings and seven under construction. The population of four hundred was almost entirely dependent for a livelihood on the Manchester, Sheffield and Lincolnshire company whose works, still incomplete, supported what was already known as a "railway colony". Some of those mentioned in the census were obviously temporary labourers, but the great majority of the population were concerned with the normal working of the company's services.

The function of the village in 1851 is revealed by the occupations of its inhabitants (Table 1). By far the largest single group of male workers in 1851 consisted of railwaymen: drivers, firemen, fitters, guards and station attendants. A large terrace of houses known as New Holland Square was occupied almost entirely by these men and their families. Another large, though numerically less important group, was associated with the river: its members were employed on the dock works, on the ferry services and as coastguards. Several builders and brickmakers lived in the village also. Bricks were made from the Humberside clays in the vicinity of Barton and Barrow long before 1851, but there is little doubt that the company's works stimulated the building trade in this neighbourhood, and in 1851 the brick industry was of some importance in New Holland itself[38].

For some services the villagers must at this time have relied upon their neighbours in Barrow and other old settlements nearby. Thus there were two butchers in New Holland but only one grocer, a resident schoolmaster and mistress but no clergyman. As the community became more firmly established, however, some of the deficiencies were remedied and by 1863 there was a small "service" group in the village[39].

Few of those whose names and occupations are recorded in trade directories in the 1850s and 1860s were born in New Holland; many indeed could scarcely have known this once empty marshland at all before 1848. The census papers of 1851 show that New Holland was inhabited by people from many parts of the British Isles. The railway company had brought together persons from as far afield as Scotland, Ireland and the south of England, and had produced a community with a great deal in common economically, but in other respects extremely varied.

Events in New Holland after 1848 soon affected places in the vicinity of the village. The railway confirmed the importance of the short and comparatively rapid passage of the Humber at this point and quickly brought to an end the coach services which served rival crossings. In November, 1848, it was reported that the "development of the [railway] company's scheme is being felt at Barton" [40], to which place

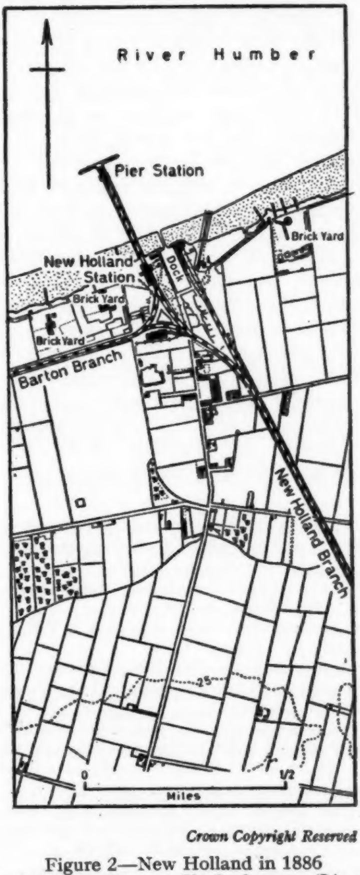

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Figure 2—New Holland in 1886

Redrawn from the Ordnance Survey Six-Inch map (Lincs. Sheet VII N.E.) published in 1890. The village has grown since 1886, and most of the land alongside the main road is now occupied by houses to a point south of the cross-roads.

a line from New Holland was then under construction. By this time the coach services from Barton Waterside to Lincoln and the south had ceased to run, as had a market day omnibus to Brigg. The opening of the Barton branch line in March, 1849, probably stimulated trade, but it marked another stage in the gradual decline of the ancient ferry between Barton and Hull, for most of the traffic bound from Barton to Hull now moved by rail to New Holland [41]. In 1851 the Barton ferry service was

discontinued for a time, and though later revived it was clearly maintained with difficulty(42). Only three years earlier a steam packet made the journey to and from Hull several times a day, but by the late 'fifties a horse boat alone remained and the frequency of the service was the same as in 1821(43).

The ferry between Barton and Hessle fared better, for when the Hull and Selby railway opened in 1840 the proprietors of the ferry timed their services to connect with trains at Hessle; and since the crossing was short and the landing facilities at this time not much inferior to those on the New Holland route, the ferry attracted a brisk trade(44). This route was also used by drovers and their beasts as they made their way south after travelling through the Vale of York, and in 1849 was claimed to form part of "the main road for the transit of Cattle between Yorkshire and the South"(45). It was customary at Hessle to ship livestock in open boats, a practice of which drovers and cattle dealers approved, since it was less likely to lead to injury than was the case when beasts were confined below, as they appear to have been in ferry boats elsewhere on the river(46). A steam packet continued to serve the Barton and Hessle route during the 1850s.

By 1860, however, the New Holland ferry service was firmly established, and with it the village. During the second half of the nineteenth century the main features of the village changed little, and in the 1880s it was still very much as the railway pioneers had known it thirty years earlier (Fig. 2). New Holland did not become a "fairyland"; its sombre red brick terraces are indeed rather undistinguished. This is perhaps as it should be, for New Holland's wonders lie in its "Works" rather than in its streets; but together they provide an interesting survival of the landscape of the Railway Age.

NOTES

(1) For example, see lists in *Battle's Directory of Hull and Beverley* (1791) pp. 63-4 (in reprint of 1885); and in *Battle's Hull Directory* (1822) p. 144 et seq.

(2) *Hull Advertiser*, 15 March 1833, 20 Dec. 1833; F. Dwarris and S. A. Rumball, *A Report of the Inquiry into the Existing State of the Corporation of Hull* (1834), p. 328 et seq.

(3) The point is well illustrated by Tripp v. Frank, 4 T.R. para. 666, 11 May 1792 (*English Reports*, 100, pp. 1234-5).

(4) 'Petition of several Persons against Mr. Trippe', 19 May 1795, contains an account of some of the hazards, Hull Corporation archives, Basement shelf 69.

(5) 'Memorial of Mayor and Burgesses of the Town of Kingston upon Hull' (undated), Hull Corporation archives, Basement shelf 69.

(6) D. Defoe, *A Tour through England and Wales* (1948) Vol. 2, p. 94: Everyman edition.

(7) *Hull Advertiser*, 21 Dec. 1821 and 28 Dec. 1821.

(8) Cases and Opinions 1811-30, 'Barton Ferry Case with the Opinion of Mr. Pattison' 1825, and Cases 1831-6, 'Case as to the Hull and Barton Ferries' 19 Nov. 1831, Hull Corporation archives, shelf 61-62.

(9) *Lincoln, Rutland and Stamford Mercury*, 15 Dec. 1848. No other reference to Dent's ferry service has been found. Barrow was enclosed in 1803, and the award plan confirms the presence of churchwarden's land by the creek.

(10) Ibid. For smuggling see also *Hull Advertiser*, 18 Oct. 1850.

(11) Cases and Opinions 1811-30, 'Case respecting the Encroachments on the Hull and Barton Ferries', 8 Oct. 1826, and 'Barton Ferry Case with the Opinion of Mr. Pattison', 1825, Hull Corporation archives.

(12) *Lincoln, Rutland and Stamford Mercury*, 15 Dec. 1848.

(13) The best account of the ferry before 1832 is contained in 'Corporation of Hull v. Lessees of Barton Ferry', 1837, Hull Corporation archives. The evidence of Robert Brown is particularly interesting. The 1846 comments occur in 'Hints for Cross Examination', petition against Humber Ferries Improvements Bill, Great Central Railway papers, Hull Corporation archives.

(14) Acland's scheme may be followed in the *Hull Portfolio*, 1831-2 and in other Hull newspapers of the period.

(15) *Hull Advertiser*, 10 Aug. 1832 and 14 Sept. 1832. See also 'Humber Ferries Bill, Robert Todd's Evidence', undated *circa* 1846, Box 2, Hull Corporation archives.

(16) *Hull Portfolio*, 22 Sept. 1832 ; and *Lincoln, Rutland and Stamford Mercury* 15 Dec. 1848. See also evidence of Robert Brown in 'Corporation of Hull v. Lessees of Barton Ferry', 1837, Hull Corporation archives.

(17) The rivalry can be traced in the *Hull Advertiser*, 1833-36, *passim*. A useful printed summary of the scheme of the New Holland proprietors is contained in 'A Map of Part of the River Humber, with the New Holland and other ferries', 1833, M6, City Reference Library, Hull.

(18) *Hull Advertiser*, 10 Oct. 1834 and 'Corporation of Hull v. Lessees of Barton Ferry', 1837, Hull Corporation archives.

(19) *Lincoln, Rutland and Stamford Mercury*, 24 July 1846.

(20) Pigot and Co., *Royal National and Commercial Directory and Topography* (1840), p. 332.

(21) *Hull Advertiser*, 14 Dec. 1832.

(22) *Lincoln, Rutland and Stamford Mercury*, 24 July 1846 and 15 Dec. 1848. Coach services were introduced in 1832.

(23) *Hull Advertiser*, 18 Jan. 1833.

(24) Ibid.

(25) M6 1833, City Reference Library, Hull.

(26) *The Illustrated London News*, 15 April 1848.

(27) *Hull Advertiser*, 18 Jan. 1833 and Robert Todd's evidence, Humber Ferries Bill. *circa* 1846, Box 2, Hull Corporation archives.

(28) W. White, *History, Gazetteer and Directory of Lincolnshire* (1856), p. 686.

(29) The purchase is described in G. Dow, *Great Central*, Vol. I, 1813-1863 (1959), p. 87 *et seq.*

(30) *Hull Advertiser*, 3 March 1848 and *Lincoln, Rutland and Stamford Mercury*, 15 Dec. 1848.

(31) *Lincoln, Rutland and Stamford Mercury*, 15 Dec. 1848.

(32) *Hull Advertiser*, 7 Dec. 1849, 19 July 1850 and 15 Nov. 1850. An interesting first-hand account of the New Holland works in 1848 is contained in Samuel Sidney, *Railways and Agriculture in North Lincolnshire* (1848), pp. 20-3.

(33) *Hull Advertiser*, 19 July 1850.

(34) Ibid., 18 Oct. 1850.

(35) W. White (1856) *op. cit.*, pp. 686-7 ; G. Dow, *op. cit.*, p. 147.

(36) *Census of England and Wales 1851*, Vol. II, Population Tables, *Lincs.*, p. 53

(37) Public Record Office, H.O. 107/2118.

(38) *Hull Advertiser*, 20 July 1827 and 16 Nov. 1832 ; H. W. Ball, *Social History and Antiquities of Barton-upon-Humber* (1856) part 2, p. 20.

(39) Morris & Co., *Commercial Directory and Gazetteer of Lincolnshire* (1863) pp. 446-7. The Church of England chapel was a chapel-of-ease of Barrow. Before 1851 services were held in the new station (*Hull Advertiser*, 18 Oct. 1850 and *Stamford Mercury*, 28 March 1851).

(40 *Hull Advertiser*, 24 Nov. 1848.

(41) *Kelly's Directory of Lincolnshire* (1855) p. 18.

(42) *Hull Advertiser*, 4 July 1851, 12 Dec. 1851, 1 March 1856 and 15 March 1856.

(43) W. White (1856) *op. cit.*, p. 695 ; W. White, *Directory of Hull and District* (1859) p.769. The Barton horse boat of this period is illustrated in *Hull Museum Publications, Quarterly Record of Additions*, No. 47 (1913).

(44) *Hull Advertiser*, 24 Nov. 1848 and 25 Nov. 1853.

(45) *Stamford Mercury*, 20 July 1849.

(46) 'Copy Petition from Cattle Dealers etc. as to the Ferries at Barton, Hessle & Hull' (undated), Box 2, Hull Corporation archives.

SALT MARSH DEVELOPMENT AT GIBRALTAR POINT, LINCOLNSHIRE

F. A. Barnes and C. A. M. King.

North of Skegness, along the open coast of Lincolnshire, erosion has predominated since the thirteenth century, driving a sand beach and dune line across reclaimed medieval or older salt marsh called the Outmarsh(1). South-west of the River Steeping's outfall (Wainfleet Haven), within the Wash, deposition and periodic reclamation of silty salt marsh have been the rule. Between Skegness and the Steeping the Gibraltar Point Nature Reserve forms an area of special physiographic interest, in which sand and shingle accumulation and fine silt and mud accretion occur in close juxtaposition, with their inter-relationships and transition forms excellently displayed (Fig. 1). Such an environment, protected from undue disturbance, forms an ideal natural teaching laboratory in which to demonstrate certain ecological principles, on account of the very characteristic and limited assemblage of plant

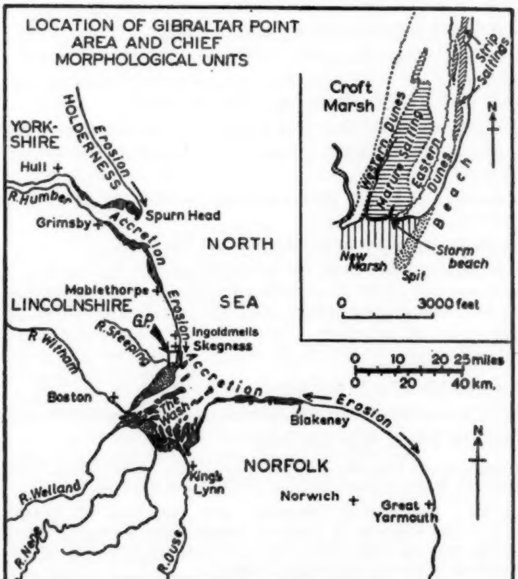

Figure 1

species in the salt marsh and dune habitats, the delicacy with which their distributions are adjusted to small variations in ground level and material, and the speed and orderliness with which changes in physiographic controls and consequently in the vegetation pattern take place.

Despite the southward drift of beach material to Gibraltar Point and beyond, the coast south of Skegness has grown out eastwards rather than southwards during the past two centuries. Its development has been pulsatory, phases of rapid accretion alternating with more stable

conditions under which long, high dune ridges were formed. These variations were influenced by movements of major offshore sand banks, and at least three such phases can be distinguished, including the current one(2).

A ridge of sand and shingle growing southwards from Skegness since the sixteenth century allowed the accumulation and progressive enclosure of Croft Marsh, in which the first major reclamations are said to date from 1608-1610(3). This valuable silty land at 9 to 11 feet O.D. (Liverpool) is several feet higher than the old Outmarsh north of Ingoldmells, aggraded to a lower high spring tide level, but somewhat lower than mature unreclaimed salt marsh nearby at Gibraltar Point. The intervening ridge on which the western dune system developed is complex, but its eastern margin is a long dune line orientated in accordance with wave conditions near the close of the first accretion phase.

In 1779 the western ridge projected almost a mile further south than at present(4), but its end decayed as beach material drifting south to feed it was intercepted at an outgrowth of the coast further north. This had certainly begun by 1824(5), and by 1870 an eastern dune system diverged from the western range south of Seacroft(6). The coast built out by successive development of gently curving, sub-parallel shingly beach ridges, with strips of salt marsh between them. This form of development progressed both eastwards and southwards during the nineteenth century, and brought into being a wider salt marsh between the western and growing eastern dune systems. Low features, little above marsh level, bordering and penetrating this salting, are recognised by their cover of *Agropyron junceiforme* (sea couch grass) and a shingly constitution revealed by boring, as stabilised former beach ridges. The long dune ridges that succeed them eastwards appear to truncate them in the north, but not in the south, and indicate the alignment of the beach later in the second major phase of accretion.

To-day the large salting is mature, and has become brackish or freshwater marsh in the north. South of a shingly storm beach which almost closes its southern end, newer salt marsh at a lower level is developing under the protection of a new sand and shingle spit(7). Its general position, variable material and developing morphology suggest similarities with the mature salting as it was a century ago, but there are also important differences. The morphology and evolution of these several types of salt marsh—the strip saltings of the open coast, the mature salting and the new salt marsh—will now be examined in turn.

The Strip Saltings

Strip saltings form when beach accretion is so rapid that beach ridges are stabilised and protected by further ridges growing seaward of them before they have been able to migrate to the top of the beach. The directions of wave approach along this section of coast are influenced by the offshore sand banks, and usually the beach ridges formed by wave action diverge southwards from the coast at a low angle. When protected by other ridges they become fixed in the north, and starved of material towards the south, so that their southern ends tend to swing round to enclose the runnel behind. This is a part of the whole process of the outbuilding of the coast under the protection of offshore banks through a local retardation of the general southward drift of beach material.

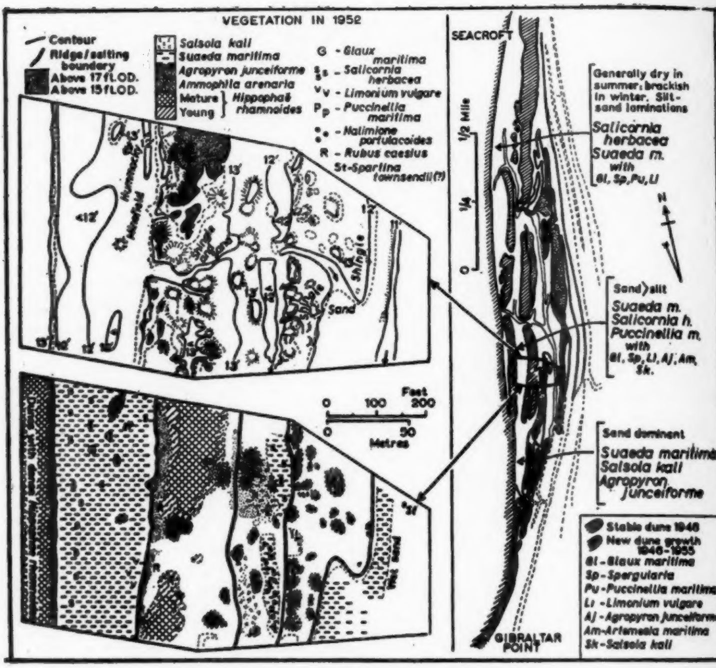

Figure 2

Strip saltings near Gibraltar Point, Lincolnshire.

Bordered by sand, the runnels build up as salt marsh strips composed of laminated sand and mud, colonised by various plants, especially *Suaeda maritima* (seablite). Salinity is maintained by periodic tidal immersion through systems of channels penetrating the ridges at intervals (Fig. 2). Because the channels may be constricted between the recurving southern end of a new ridge and the earlier ridge to landward, whose face may be eroded, the draining water after high tides can cut deep scour holes, and keeps the outlets open for some time. But eventually the outlets become blocked by sand, and thereafter, with blown sand alone added, the strips enter upon a new phase of ecological development as major dune slacks at about high tide level. Even before blockage small dunes colonised by *Salsola kali* (prickly saltwort) and *Agropyron junceiforme* (sea couch grass) often develop within the strips (Fig. 2), while as soil salinity lowers many other plants enter the succession, to which *Hippophaëtum rhamnoides* (the sea buckthorn association) appears to be the climax.

The Mature Salting

The mature salting, behind the storm beach, drains west to Main Creek. Its middle tract generally resembles that south of South Marsh Road (Fig. 3), to which discussion is now confined.

South Salting has several distinctive parts, differing in constitution and vegetation. The western half is composed of fine silt and contains all the surface drainage channels except one. Its characteristic vegetation

(Fig. 3) is a dense *Halimionetum portulacoides* (the sea purslane association) on the gently concave interfluves between 11.2 and 11.7 feet O.D. and on the inner creek banks, giving way to *Agropyron pungens*(8) on the higher, better-drained levées at 11.75 to 12.75 feet. Still flooded by the higher high spring tides the *Halimionetum* is still being raised slowly by silt deposition, and its borders invaded by *Agropyron pungens.* Upgrowth of the creek levées was probably quickest when they carried *Halimione portulacoides: Agropyron* tolerates only occasional immersion, and further upgrowth of the levées depends mainly on humus formation. There are small patches of *Artemesia maritima* (sea mugwort), and patchy *Puccinellia maritima* (sea grass) especially in former pans(9), but *Halimione* and *Agropyron* are overwhelmingly dominant.

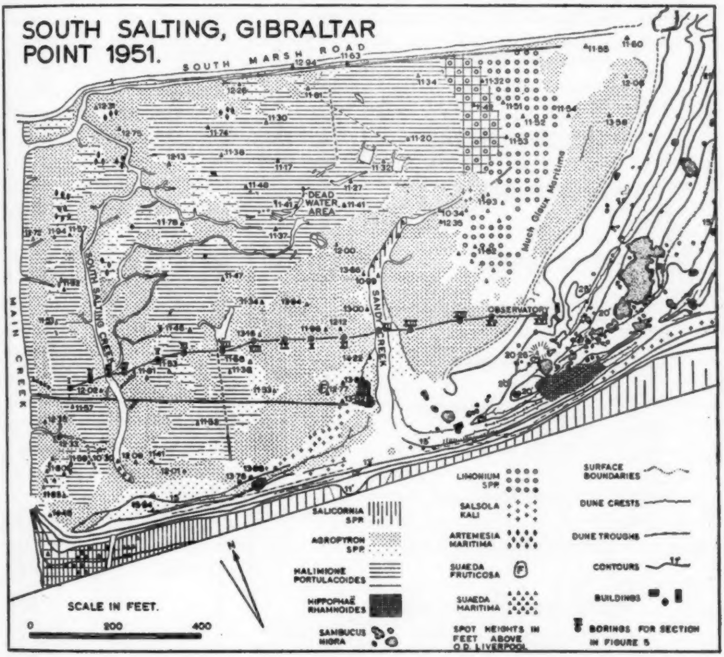

Figure 3

Further east, with more sand in the deposit, the *Halimionetum* gives way to vegetation associations dominated by *Puccinellia maritima* and species of *Limonium* (sea lavender). This firmer ground was damaged by vehicles during the war, but after a recovery phase in which *Glaux maritima* (sea milkwort) and *Suaeda maritima* (seablite) were very prominent the *Limonietum* is now restored, while since myxomatosis eradicated rabbits *Puccinellia* has become very prominent. The *Limonietum* is very level at 11.5 to 11.55 feet O.D., falling an inch or two to the *Halimionetum.*

A third distinctive unit of South Salting is the area of hummocky sand in the south-east, covered with *Agropyron junceiforme,* generally about one foot above the general marsh level, and bisected by Sandy Creek. This is discussed later.

Two drainage features of the silt marsh deserve mention. Nearly all its drainage enters Main Creek in the north-west corner, either through the channel alongside South Marsh Road or gathered by South Salting Creek. The creeks are almost entirely enclosed by levées, and are contracting. While primary depression pans are rare, blockage of the upper parts of creeks aided by vegetation growth has produced groups of secondary pans aligned with still-active creeks, and either bare or containing only *Puccinellia maritima* (sea grass). However, there is no sign yet of the complete blocking of the creek heads which would cut off the *Halimionetum* from regular immersion in sea water, and lead to its replacement by brackish or freshwater land vegetation.

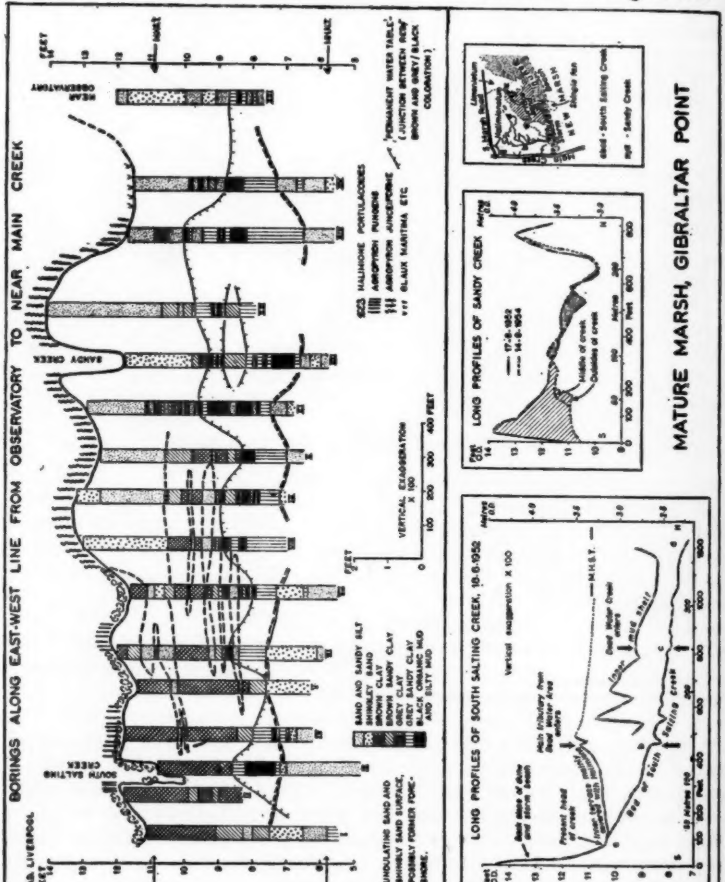

Figure 4 Borings and creek profiles in South Salting, Gibraltar Point.

The decay of *Halimione* east of the head of South Salting Creek in 1951 (revived since 1953 by a new breach through the storm beach) may have been associated with the reversal of that creek. It tributaries are aligned as if it opened south, and its channel widens towards its blind southern end. According to local information South Salting Creek was

blocked by the storm beach in 1922([10]). Its present head is wide and deep, and covered by vegetation, but northwards a bare incised channel rapidly deepens (Fig. 4). Long-profiles of the small paired inner terraces show these to grade down to the blind end, and they may represent the bed of the creek prior to 1922. But further north paired, bare inner shelves grade down northwards, and since the 6-inch map of 1904 shows a south-opening creek from the junction with Dead Water Creek (c in Fig. 4) beyond which a deep cut now joins it to the South Marsh Road channel, something more than simple reversal may be involved.

Sandy Creek is quite different. In 1952 its mouth was blocked by the ridge of the storm beach, though water entered by seepage, and at exceptionally high tide sand and shingle were washed in and out, forming fans round its head and mouth. Since the 1953 storm tide opened the mouth of Sandy Creek this washing of material has been frequent, and much sand has been spread over the mature marsh, especially to the east of the head of the creek. The second and more recent (1953) cut through the storm beach dune ridge further west has developed over the last eight years in a way that illuminates the probable origin of Sandy Creek. The new channel now (1961) is also associated with considerable spreads of sandy shingle, both over the surface of the mature marsh and around its opening on to the new marsh, where a deep scour hole has developed.

Borings across the south of the salting (Fig. 4) reveal black mud beneath both South Salting and Sandy Creeks, 5 or 6 feet below the present marsh level of 12 to 14 feet O.D. It lies in hollows of an undulating sandy and shingly surface which may represent a foreshore immediately antedating the shingly foundation feature of the eastern dune system in this vicinity. The section drawn from the boring data suggests that silt is widespread up to 9 to 10 feet O.D., though sand layers are prominent between the two creeks. Above this level, however, deposition near South Salting Creek has been almost entirely of silt, while near Sandy Creek there are several feet of sand containing shells and shingle which suggest that most of it was washed on to the marsh surface during storms.

The New Marsh

Further light may be thrown on the development of the mature salting by study of the new salt marsh that is evolving south of the storm beach. The destruction of the hook of a spit terminating the western dune system alongside the Steeping since 1904([11]), and the northward transgression of the storm beach over marsh deposits, as revealed by digging, imply the removal of some protective feature probably prolonging the eastern dunes. The hard shingle bands mapped in the New Marsh in 1951 (Fig. 5) may be significant relics, although alternatively they may be merely remnants of shingle spreads from Sandy Creek. Still more recently, however, this area has undergone accretion behind the present spit, a prominent feature extending south from the present Point, the northern end of a longer, lower bank that diverts the Steeping estuary far south of its position 50 years ago. Though not prominent in 1946([12]), the spit was high enough by 1950

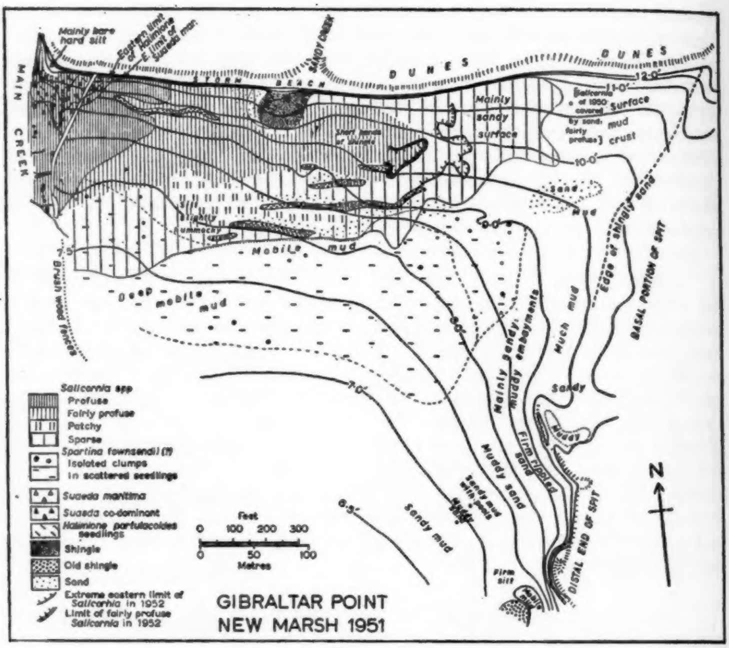

Figure 5

to carry dune vegetation[13]. It has provided effective shelter from open sea waves, except those markedly refracted and therefore low, to allow a rapid accumulation of silt behind it.

In 1951 the embayment behind the spit was almost flat below about 7.5 feet O.D. before sloping to the Steeping channel, and its slope remained less than 1 in 350 along its axis. But elsewhere the slope, deposits and vegetation varied, contrasting with the more monotonous belt of marshes beyond the Steeping, and sand formed an important element in the deposits.

In the north-west corner (Fig. 5), between Main Creek and the former South Salting channel, well-drained firm silt, probably mainly contemporaneous with that of the mature marsh, carried profuse *Salicornia herbacea* (glasswort), with much *Suaeda maritima* (seablite) and scattered *Halimione portulacoides* (sea purslane) seedlings—the most advanced vegetation on the marsh. In the north-east rapid sand deposition was inhibiting *Salicornia* growth, and the boundary of the *Salicornietum* was retreating westwards. Moribund clumps of *Spartina townsendii* (rice grass)[14] above 10 feet O.D. suggested heavy deposition of sand, mainly washed over the spit.

Southwards from the north-west corner the silt softened as the slope flattened : *Salicornia* became sparser and was joined by *Spartina* seedlings, most numerous between 7.5 and 8 feet O.D., and becoming very scattered below 7 feet, where the deep mud was too fluid for *Salicornia*. In the middle section of the marsh the boundary between

fairly firm silt, sand or shingly material carrying *Salicornia*, and mobile mud with only *Spartina* seedlings was often very sharp, and rose in level eastwards to where mud became patchy, especially above 9 feet O.D., and firm shingle absent or buried. Clearly the relative distribution of *Salicornia* and *Spartina* was closely controlled by lithology as well as by frequency of immersion. In the north-east corner of the marsh thin lamination of mud and sand was related to varying tidal and weather conditions. In the east sand or muddy sand was predominant, partly blown, but mainly washed over the spit or through the depression across it, and the only thriving vegetation was two small isolated clumps of *Spartina* at about 7 feet O.D. behind the distal end of the spit. Elsewhere a few isolated *Spartina* clumps occurred at heights between 7.2 and 9 feet O.D. No *Aster tripolium* or *Puccinellia maritima* were found anywhere in the New Marsh.

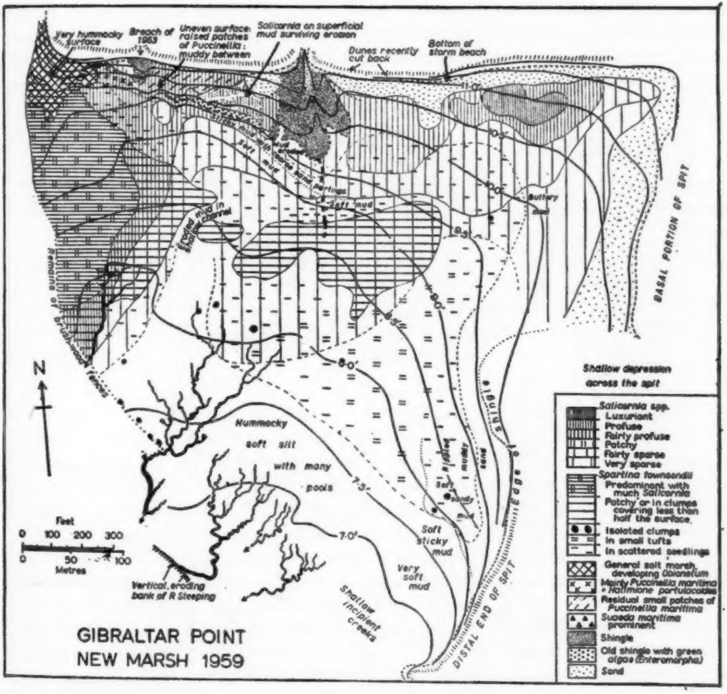

Figure 6

Most of the New Marsh was slob land, on which creeks had yet to form, the only channels in the north being short cuts to Main Creek. Developing creeks opening south into the Steeping did not extend back above about 6 feet O.D., well below the lowest vegetation.

Since 1951 the marsh has developed considerably. Periodic profiles surveyed across the embayment show that apart from the sand washed in by the 1953 storm surge the level has built up steadily by some 8 inches at the axis, decreasing to 3 to 4 inches in the *Salicornietum*,

where erosive episodes have intervened, and beyond which the storm beach and dunes have been cut back about 30 feet over 7¼ years. Mud deposition has become more widespread, allowing a sparse growth of *Salicornia* east of the axis of the embayment (Fig. 6).

A complete re-survey of the New Marsh in late 1959 has been used, with the 1951 survey, to derive isopleths of accretion (Fig. 7). These indicate considerable variations. Over the 8½ years accretion was heavy, over 3 feet in places, where there is muddy sand below the inner beach of the distal end of the spit, and amounted to more than one foot opposite the transverse depression—rapid rates related to the high proportion of sand in the deposit. In the middle section of the marsh accretion increased outwards from a zone of net erosion near the beach[15] to a maximum of almost one foot of silt in the lowest zone with vegetation. This figure, which equals an average 3 cm. a year, is over three times as great as the rates of 0.4 to 0.98 cm. a year measured in various marshes in Norfolk, and 0.86 and 0.88 cm. a year in the *Puccinellietum* of the Dyfi estuary[16]. Alongside Main Creek, moreover, fine silt has accumulated to depths up to 1.5 feet, an average rate

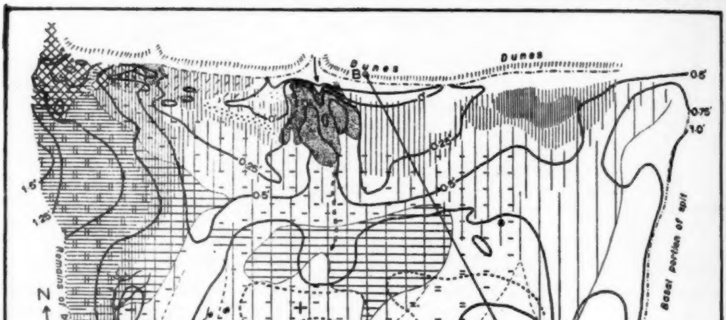

Figure 7
Accretion and vegetation in Gibraltar Point New Marsh

of up to 5.5 cm. a year, a very rapid rate indeed. In the close relationship of the isopleths there to the development of a *Spartina* meadow is striking evidence of the efficiency of *Spartina townsendii* in trapping silt, and of the rapid spread of *Spartina* in conditions of rapid silt accretion.

A few further points concerning vegetation changes in the New Marsh should be mentioned. The extreme north-west has developed normally from the *Salicornia-Suaeda* association to "general salt-marsh" in which *Halimione portulacoides* is becoming dominant in a dense cover, and *Aster tripolium* and *Puccinellia maritima*, both absent in 1951, are well represented. Eastwards, hummocks carrying *Puccinellia* and some *Halimione*, with steep sides which show that they are residual remnants, indicate ecological progress despite erosion, while east of the mouth of Sandy Creek *Salicornia* has spread back eastwards. Most striking progress has been made by *Spartina*, which has gained a foothold in the new *Halimionetum*, and below it forms a dense meadow, within which, however, *Salicornia* is still profuse on slightly higher patches of silt. Seawards and eastwards the *Spartinetum* breaks into patches and clumps, while still lower fairly sparse *Salicornia* shares a zone with scattered *Spartina* seedlings.

Further east *Spartina* clumps occupy a formerly very mobile area below the now buried shingle bands, extending east to the embayment axis, and a muddy zone immediately above this *Spartina* belt, perhaps slightly sheltered by it, and now shared by *Salicornia* and *Spartina* tufts, appears favourable for a rapid further development of *Spartina*. In the east sparse *Salicornia* occurs north of the depression across the spit, on a sandier surface, and *Spartina* seedlings south of it where there is more mud.

Many of the morphological features of the New Marsh are reminiscent of those of South Salting, and were *Spartina* absent the development of a *Halimionetum* and *Agropyretum* in the north-west, of a *Limonietum* in the north-east, and of a sandy area like that around Sandy Creek behind the spit depression might have been forecast. But *Spartina* colonisation will have important effects, especially in bringing more rapid accretion to low tracts of soft mud. Its influence on drainage evolution will be watched with special interest. At present the marsh above 8 feet O.D., and in the east above 7 feet O.D. is slob land, but in the south-west creeks are workings headwards from those noted earlier entering the Steeping, aided by the prolonged drainage from the level marsh compared with its rapid flooding on the rising tide, and further promoted by erosion on the Steeping's outside bend. Some creek heads have reached *Spartina* patches, and here their detailed alignments appear to owe something to isolated *Spartina* clumps. Through scouring these are surrounded by water-filled depressions, and drainage initially takes place from clump to clump. Once formed the creeks' banks are favourable environments for the rapid spread of *Spartina* clumps. In the denser *Spartina* meadow there is as yet little evidence of channels. It will be interesting to compare the influence on drainage development of *Spartina* growth in its different forms and on different types of material.

Any attempt to forecast the future pattern of development of the New Marsh on the basis of recent changes is a hazardous undertaking, for the fate of the Marsh will depend upon the future development of the spit, and this may take one of two courses, or a combination of them. The rapid erosion on the outside bend of the Steeping may lead it to break through eastwards to the sea, and to destroy part of the marsh, if not part of the spit itself([17]). If the spit escapes destruction by the Steeping its future will be determined mainly by developments in the zone of accretion to the north, themselves dependent upon movements of offshore sandbanks. The beach accretion, working slowly southwards, will alter the wave alignments as well as intercepting material moving along-shore southwards to feed the seaward face of the spit, and these factors will cause the spit to swing over the south-east of the marsh, as forecast in 1957, and to decay as a hook. It may be significant that during the past few months the southern part of the spit has been observed to move many feet westwards, and it may be that its forecast encroachment on the New Marsh is now accelerating.

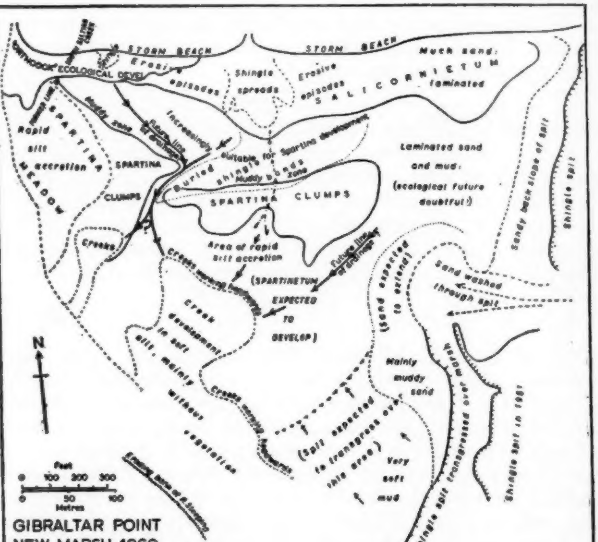

Figure 8

It has been noted that although erosion has continued at the northern boundary of the New Marsh, accretion has been general elsewhere over the past decade. Erosion may not become general in the marsh until the spit is in an advanced stage of decay. In the meantime it seems likely that *Spartina* will increasingly dominate the lower areas of the New Marsh (Fig. 8) and as the slope decreases the sandier northern zone will drain through creeks penetrating a *Spartinetum*. Already erosion of mud in a slight channel breaking the zone of *Spartina* clumps may presage creek development linking with the Sandy Creek outlet; and there are also other pointers. But eventually radical changes must be

expected as erosion extends. Timing is almost impossible, however, and the exact form of the New Marsh after a further decade of development cannot be predicted. The balance between erosion and accretion is likely to tip gradually in favour of the former until a critical point is reached when erosion will rapidly become predominant, but this will be the outcome of a complex of forces external to the marsh and largely unmeasured.

NOTES

(1) A. E. B. OWEN, Coastal erosion in E. Lincolnshire, *Lincs. Historian* 9 (1952) 330.
F. A. BARNES and C. A. M. KING, The Lincolnshire coastline and the 1953 storm flood, *Geography* 38 (1953) 141-160.
H. H. SWINNERTON, The physical history of E. Lincolnshire, *Trans. Lincs. Naturalists' Un. 1936*, 91-100.

(2) F. A. BARNES and C. A. M. KING, The spit at Gibraltar Point, Lincolnshire, *East Midland Geog.* 8 (1957) 22-31.

(3) D. N. ROBINSON, Unpublished B.Sc. dissertation (1952), Dept. of Geography, Univ. of Nottingham.

(4) A. ARMSTRONG, Map of Lincolnshire (1779).

(5) O.S. 1 Inch to 1 mile map: First Edition (1824).

(6) O.S. 1 inch to 1 mile map: Second Edition (1870).

(7) BARNES and KING (1957) op. cit.

(8) It is thought that a hybrid *Agropyron* is also present in South Salting, but *A. pungens* is probably dominant.

(9) Pans are areas of salt marsh that are not drained by channels and which, being slightly lower than the general surface of the marsh, contain standing water after high tides. As a result of evaporation of sea water their soils are abnormally saline, and consequently their ecological development is retarded, so that they are usually bare of vegetation in young marshes, and contain vegetation characteristic of an earlier stage in the vegetation succession in more mature marshes. They may persist from the first stages of colonisation of the marsh by vegetation (primary depression pans) or they may develop subsequently through uneven deposition of sediment, or the blocking off of creeks to form secondary or channel pans.

(10) Information from Mr. F. S. W. Major of Skegness.

(11) O.S. 6 inches to 1 mile map (1904). See also BARNES and KING (1957) op. cit., Fig. 1.

(12) Royal Air Force vertical photographs.

(13) C. G. C. CHESTERS, A preliminary account of the vegetation of the foreshore from Seacroft to Gibraltar Point, *Bird Observatory and Field Research Station, Gibraltar Point, Lincs., Report for 1950* (1951) 48-57.

(14) *Spartina townsendii* is the name of a presumed hybrid, but the rice grass common at Gibraltar Point continues to seed vigorously and profusely. It is here called *S. townsendii* in the expectation that the name may be retained for this plant if it is accorded species status.

(15) Dune erosion at the top of the storm beach, which has been intermittent over the past decade, has been more active in 1961 than in previous years.

(16) J. A. STEERS, *The coastline of England and Wales* (1946) pp. 525-535.

(17) The River Steeping followed such a more direct eastward course in 1904. See BARNES and KING (1957) op. cit., Fig. 1.

SURFACE BREEZE EFFECTS OF LEICESTER'S HEAT-ISLAND

T. J. Chandler

Man is constantly modifying the climate of his surroundings, for any change in the landscape will necessarily affect local atmospheric conditions. All changes of vegetation and of surface water features, for instance, will influence nearby air temperatures and humidities, but there is little doubt that one of the most notable man-modified climates follows the congregation of buildings in hamlets, villages and towns. Each building creates its own microthermal conditions, macadamised roads affect nearby temperature, evaporation and run-off, mounds of industrial waste and railway cuttings initiate new slope climates, while man-made structures exert a mechanical and possibly a thermal influence upon the airflow around them. In large towns these and similar changes are so strongly developed as to create a distinct climatic region roughly coincident with the built-up area.

Towns are generally characterised by temperatures higher than in the surrounding rural districts, the degree of warming depending upon a number of factors including cloud amount, preceding and present temperatures, humidity, wind velocity and direction and the extent and morphology of the urban area. The temperature difference between a city and its rural surroundings is generally strongest by night, with isotherms describing "islands" of warm air within and above the major centres of settlement.

The night-time temperature pattern in an area of closely-spaced settlements may be compared with that of an archipelago during a warm summer's day: in both cases 'heat-islands' will develop and theory suggests that local winds similar to sea breezes will develop around the margins of towns. There are a number of references in the literature to the possible existence of such an urban 'heat-island' circulation (Gold 1956, Berg 1957) and this has been substantiated during an intensive investigation of London's climate (Chandler 1960) although the extent of London gave rise to a variety of experimental difficulties for the field investigation. More particularly, it was not possible, at the time, to include temperature traverses across the whole width of the city. For this reason, and in order to test certain theories, a number of temperature traverses across Leicester were carried out during April, 1960.

Leicester was considered large enough to produce a substantial urban modification of the climate, but at the same time its limited extent and generally compact form would permit traverses across the whole width of the city during the time regional temperature changes normally remained approximately rectilinear in form. One temperature traverse on the night of April 11-12 is particularly interesting, for it shows the important influence of local winds, similar to sea breezes, upon the degree and form of the 'heat-island' above the city. It illustrates the way in which country air, especially in the early part of the night, entered the fringes of the city in a series of pulses, like miniature cold fronts, first on the leeward side and then the windward side.

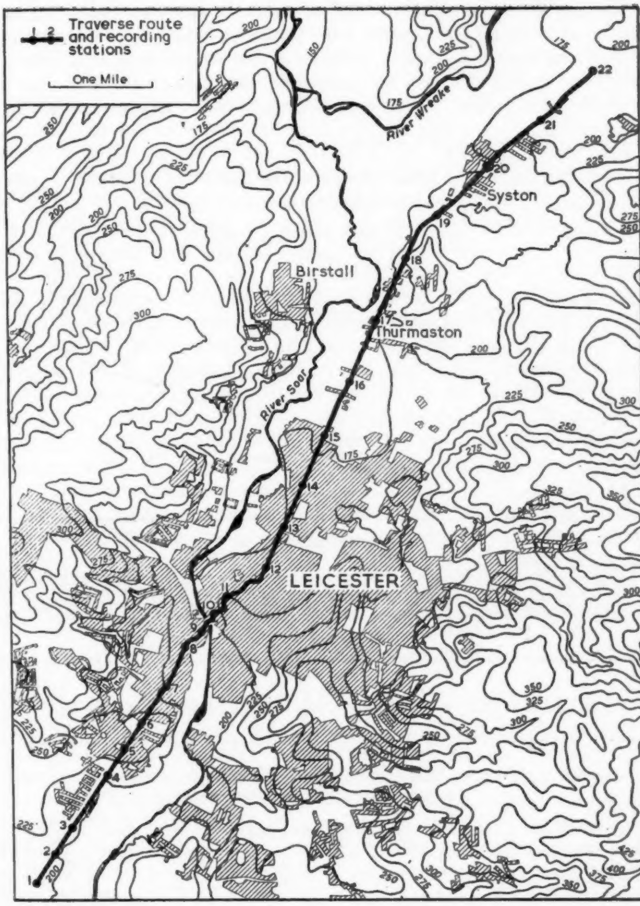

Figure 1

Temperature readings were obtained from an electrical resistance thermometer housed in a double radiation shield mounted at the side and to the rear of the survey car (Chandler, 1960). Leads from the element were connected to galvanometers inside the vehicle. In order to ensure that engine heat did not affect the readings, and that the thermometers were sufficiently sensitive, short closed traverses were made across areas of marked temperature change. Readings during these initial test runs showed no noticeable influence of engine heat upon the thermometers but in order to be absolutely sure of non-interference, the bonnet of the survey car was covered by a thick pad of glass fibre.

In Leicester, the selected line of traverse followed the floor of the wide, shallow Soar and Wreak valleys with only small changes of altitude. Nearly all local temperature changes can safely be accredited to the influence of the built-up area. The starting point of the traverses

(Fig. 1, station 1) lay in the rural districts south-west of the city and the route led through the central area (stations 8 to 12) to the more open parts north-east of Leicester. The first double traverse continued well beyond the edge of the city (station 15), through a number of small settlements such as Thurmaston, to the terminal (turning) point (station

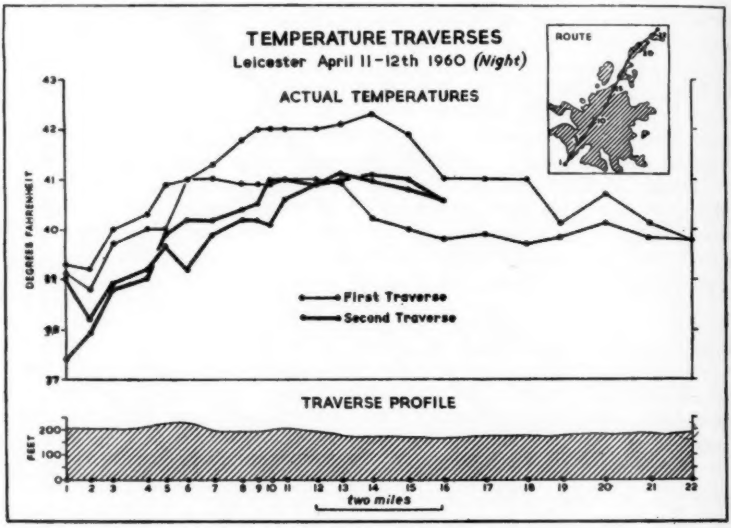

Figure 2

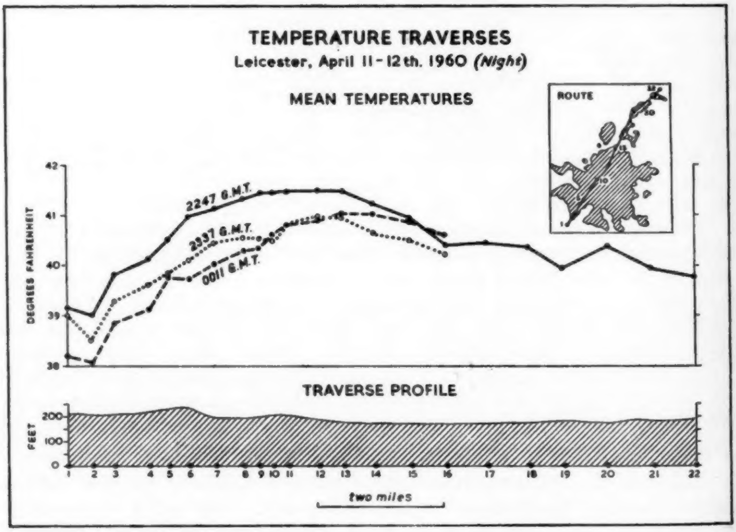

Figure 3

22) north-east of Syston. The second double traverse ran to and from station 16. In each case, temperatures were read at the same closely spaced points along both outward and return legs of the double traverse. Thus if regional temperature variations during the period of traverse were rectilinear at each station, and the timing of each leg the same, then the mean of the two readings at each station gives fairly accurately the temperature there at the time the mid-point (station 16 or 22) was reached. Then with two double traverses, three mean temperature profiles (Fig. 3) can be drawn. A thermograph sited a short distance south-west of the city was used to check the rectilinear form of regional temperature changes during the period of traverse.

Figures 2 and 3 show the results obtained during one of the series of temperature traverses conducted during April, 1960, and they illustrate several points of general interest. On the 11th, the British Isles lay near the north-eastern margins of an extensive Azores anticyclone; winds were westerly and cloud amounts varied between five and eight-eighths, giving long sunny periods, during the late morning there were a few light instability showers. Temperatures rose to the upper fifties. A traverse during the morning revealed only a small urban effect (1.4°F extreme urban-rural temperature contrast at 9.25 GMT) and the temperature profile across Leicester was rather irregular, probably owing to local thermals. During the evening, cumulus clouds dispersed leaving a five-eighths cover of cirrus at approximately 25,000 feet. West-south-westerly winds of about ten knots blew outside the city, but with increased friction, windspeeds were no doubt sharply reduced near ground level within and to the lee of the built-up area : here average speeds were probably no more than four to six knots.

After sunset, temperatures fell more rapidly in the rural areas around the city than in the built-up areas, thus intensifying a positive temperature anomaly within the city. The reasons for the differential rates of warming and cooling are no doubt complex but horizontal off-screening of terrestrial radiation, heat radiation from the fabric of buildings, counter radiation from atmospheric pollution and direct heating by combustion are probably the most important. The form of the warm air or 'heat-island' above Leicester changed appreciably during the period of traverse between 2159 GMT on the 11th and 0046 GMT on the 12th, mainly in response to the changing relative strength of regional and local winds.

During the first crossing of the city (between 2159 GMT and 2337 GMT), the urban-rural temperature contrast was about 3.1°F at 2229 GMT, the time station 14 was reached (Fig. 2, uppermost line). The highest temperatures were found in the eastern parts of the city (stations 10 to 15). Earlier in the evening, the westerly (regional) winds had carried warm air into the eastern suburbs of Leicester—air which was warmed as it slowly crossed the central and eastern parts of the city. On the windward, western, side, advection and the vertical heat transfer of atmospheric turbulence led to a smoothing of temperature contrasts which contrasted with the steeper thermal gradient built up along the eastern margins of the city. Thus, along the line of traverse and during the first crossing of the city, there was a pronounced but gentle temperature increase from station 1 to the central districts. Here tem-

peratures remained constant before rising a few tenths of a degree to a maximum at station 14, very near the limits of the main built-up area. In the next mile, temperatures fell sharply by 1.3°F to the more open area between Leicester (population 285,000 in 1951) and the small settlement of Thurmaston (population 4,200 in 1951). From here, station 18, temperatures fell to a minimum of 39.8°F in the rural area around station 22, except for a small 'heat-island' of 0.6°F around Syston (population 5,500 in 1951)—station 20.

Along the line of traverse, with its series of small settlements north-east of the main built-up area, the thermal gradient near the city margins was no doubt less than across much of the remaining eastern city boundary where temperatures probably fell by at least two degrees in one mile.

The first crossing of the city, then, showed a shift of warmer air to the eastern suburbs of Leicester. It is likely, however, that the temperature profile during the first crossing represents an already somewhat degraded form of an even steeper eastern margin to the 'heat-island' which existed earlier in the evening. This is suggested by temperature readings during the return leg of the first (double) traverse for this points to the existence of a thermally induced near-surface return flow of air normal to the steep thermal gradient, bringing cool country air into the eastern suburbs. The warm air above the main body of the city was no doubt rising (Kratzer 1937, Balchin and Pye 1947), although there is also evidence in the traverse readings of a slight westerly, horizontal displacement. The shallow inward-moving cool country air progressed only a short distance into the city, no doubt owing to the great frictional drag of the buildings and the associated smoothing of the temperature gradient. The movement was, however, sufficient to displace the heart of the 'heat-island' to the central parts of the city, and by 2337 GMT, the end of the second or return leg of the first traverse, its western edges were steeper than those on the east. Calculations using a modification of Gold's formulae (Gold 1910) and assuming negligible friction outside the built-up area and a small depth (300 feet) to the warm air, indicate that the thermally induced easterly current would have a speed of about 4 knots—a speed comparable to the calculated near-surface windspeed on the leeward side of the city and normal to its margin. The comparability of regional and opposing thermal wind-speeds no doubt accentuated the pulsating movement of the local front across the eastern suburbs of Leicester.

The first double traverse of the city also illustrates the more rapid formation of cold pools of air in rural than in urban districts. Station 2 lies at the bottom of a very shallow valley cut into one of the Soar terraces. This is obviously a pronounced frost hollow—a feature which developed more strongly as the night progressed. Equally intense relief features within the urban area of Leicester did not show an effect of comparable intensity.

Further evidence of the backward and forward, pulsating, movement of the warm air within Leicester, and especially its eastern, leeward margins, is given by the record of the second double traverse (Fig. 2) and by the changing form of the three mean temperature profiles based upon the four crossings of the city (Fig. 3).

During the outward leg (from station 1 to 16) of the second traverse, which took place between 2338 and 0046 GMT, temperatures in the western suburbs fell more rapidly than either previously or subsequently during the investigation. This is probably explained by the retreat, during this time, of the fairly steep edge of the 'heat-island' which then lay mainly in the central districts and western suburbs; a movement similar in origin and consequences to that already described on the opposite side of the city during the time of the previous traverse. On this second occasion the thermal current was reinforced by the regional winds and the result was to appreciably increase temperatures at stations 10 to 15 as warm air replaced cool country air which had previously entered these parts. During the time of the return leg of this second traverse (Fig. 2), temperatures continued to rise at many of the north-eastern stations, but the increase at stations as far to the south-west as station 5 suggests yet another pulsation of warm air toward the western districts of Leicester.

The sharp fall in temperature at station 6 during the first or outward leg of the second traverse was not repeated during the second or return leg. This is very interesting for it probably indicates the influence of local air movements, such as those described above, upon the depth of the warm air above the city and thus upon the lapse rate. During the first leg of the second traverse, warm air was moving eastwards and was replaced by cooler air. The warm air above the western suburbs was probably exceedingly shallow and the lapse rate steep. Thus, at station 6, the most elevated station of the whole traverse, temperatures were less than in lower-lying parts of the route. At the same station, 47 minutes later, warm air was moving back again and deepening in the western parts of the city, and the temperatures showed no effect of altitude, a local urban effect more than compensating for increased station height.

Conclusions and Implications

The main features of one night's traverses, described above, were repeated, though in a less intense form, on other nights during the series of traverses across Leicester. They clearly indicate the existence of thermally induced near-surface currents, closely akin to sea breezes, which modify the wind and thermal structure of town climates. The movement of these currents is characteristically pulsating, developing alternately on the windward and leeward sides of the city and gradually reducing the sharpness of the urban-rural temperature contrast. Such local winds must also influence other climatic elements such as the frequency of fog and instability showers, and also the distribution of pollution.

The onset of a 'heat-island' circulation, with cool surface air moving across the fringes of a city toward the warmer central districts has been suggested as a possible explanation of the characteristic secondary evening peak in the daily pollution cycle (Munn and Katz 1959). This type of circulation, proved in Leicester and London, may also partially explain the strikingly small downwind shift of the point of maximum pollution concentration as found during the Leicester Survey of 1937-39 (Atmospheric Pollution in Leicester 1945). Near-surface return currents on the leeward side of the city, similar to those

described above, probably bring cleaner air into the suburbs and thereby dilute pollution concentrations. They may also assist in the escape of pollution vertically. The central districts generally remain beyond the reach of such shallow, weak currents, and consequently record higher pollution figures than either the windward or leeward sides of the city.

ACKNOWLEDGEMENTS

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THE MACKINDER CENTENARY IN THE EAST MIDLANDS

K. C. Edwards

Sir Halford Mackinder, who died in 1947 at the considerable age of 86, was recognised as one of the leading figures in public service and one of the greatest teachers of his time. Halford J. Mackinder, a native of the East Midlands, was born at Gainsborough on February 15th, 1861. He attended the grammar school in that town for a few years before going to Epsom College and thence to Christ Church, Oxford. His university career was one of rare brilliance for he read two honours schools, Natural Science and Modern History; he was President of the Union and was then called to the Bar.

For many years he devoted a large part of his energies to the study and teaching of Geography. Through his immense scholarship, imaginative ideas and stimulating lectures, Mackinder virtually re-formulated the content and presentation of Geography. In stressing the importance of spatial relationships between groups of phenomena on the earth's surface and in developing new concepts of regional study, he laid firm foundations for the subject in our educational system. Through his efforts Geography was introduced to our universities, though this was long after its acceptance in many other countries. Some issues, which many still find perplexing, Mackinder saw clearly. He insisted that geographers must have a basic training in the techniques of several subjects which, incidentally, is a very different matter from merely dabbling in other fields of knowledge. He showed that the integration of geographical phenomena is a creative process, that spatial correlations lead to discoveries, and in any case to a fuller understanding of the mutual relationships between Man and the Earth. Mackinder also advanced the claims of Geography to bridge the deepening gap between the natural and the social sciences, "the abyss which is upsetting the equilibrium of our culture".

In the eight years following 1885, Mackinder gave courses on what he called the New Geography for the Oxford University Extension movement in nearly fifty different towns throughout England. In the East Midlands such courses were held at Lincoln, Worksop, and in his native Gainsborough. These lectures drew large audiences and were always an exhilarating experience. In 1887, when barely 26 years of age, Mackinder read to the Royal Geographical Society his paper "On the scope and methods of Geography". This made such an impression on his elders that he was soon appointed to a Readership in the subject at Oxford, the first university post in Geography in this country. He remained at Oxford until 1905, though for some years previously he gave courses at the Reading College (later the University of Reading) and the London School of Economics and Political Science. At the latter institution he not only founded the Department of Geography but eventually became Director of the School.

A man of impressive intellect, strong constitution and forceful personality, Mackinder applied his energies to a remarkably wide range of activities embracing education, administration, politics and other fields of public service. As an explorer he made the first ascent of Mount

Kenya. As an educationist he was not only the pioneer of modern Geography in Britain but was an indefatigable worker in the cause of adult education—in one year alone, despite pressing demands on his time, he gave more than a hundred lectures in different parts of the country, travelling some 30,000 miles. In 1933, comparatively late in his career, he lectured in Nottingham at the former University College, his subject being "The Geographical Way of Thinking."

To commemorate the centenary year of Mackinder's birth a plaque presented by the Lincoln Branch of the Geographical Association was unveiled in the entrance hall of the Queen Elizabeth Grammar School, Gainsborough, on May 4th 1961, by Professor S. H. Beaver, President of the Branch. Among those present were officers and members of the Lincoln Branch of the Association, members of the Nottingham Branch including Prof. K. C. Edwards (who as president of the Lincoln Branch in 1953 first ventured the idea of the plaque), the Headmaster and Governors of the School and, to the great satisfaction of all, Dr. Hilda Ormsby, the only surviving member of the staff who served with Mackinder in the early years of the Department of Geography at the London School of Economics. In a short address Prof. Beaver outlined the career of Mackinder, who was a pupil at the Gainsborough School from 1870 till 1874, and reviewed both the inspiring nature and importance of his contribution to Geography through writings, research and teaching. Prof. Beaver pointed out that, although Mackinder is closely linked with Oxford, much of his work was done during his time at the London School of Economics. The two best known books, *Britain and the British Seas* (1902) and *Democratic Ideals and Reality* (1919), both date from this period.

The plaque, designed and executed by Mr. L. Atkinson, A.R.C.A., of the Lincoln Training College, is in dark green Westmorland slate and carries the following inscription :—

SIR HALFORD MACKINDER

1861-1947

FATHER OF MODERN BRITISH GEOGRAPHY

BORN IN THIS TOWN AND FIRST EDUCATED AT THIS SCHOOL.

This simple memorial will serve not only to perpetuate Mackinder's name in his native town but should serve as an inspiration to young geographers attending the School where he himself was nurtured. In a wider sense it recalls the life-work of an outstanding personality in scholarship, education and public affairs.

POPULATION CHANGES IN ENGLAND AND WALES, 1951—1961

R. H. Osborne

The sixteenth census of England and Wales was taken on 23 April, 1961. Provisional population figures for counties and for their constituent local government areas have recently (June, 1961) been published in the *Preliminary Report* issued by the General Register Office. The following commentary and accompanying map have been compiled in order to give readers a broad outline of the salient changes that have taken place in the last ten years. Some of the points are derived from the *Preliminary Report*, while others are observations by the present writer.

The National Picture

At 46,072,000 the 1961 population was the highest ever recorded. Of this total 43,431,000 were enumerated in England and 2,641,000 in Wales. These figures relate to the actual (*de facto*) population at the time of the census and thus include both natives and foreigners and both civilians and members of the Armed Forces. The increase since the fifteenth census, of 1951, was 2,314,000, or 5.3 per cent (0.51 per cent annual average). The absolute increase was the highest since the decade 1901-11, although the annual average percentage rate was less than half as large and was also somewhat below that for 1921-31.

The increase was accounted for by a natural increase of 1,962,000 and a net inward migration movement of 352,000 from the rest of the world, including Scotland and Ireland. These figures may be compared with those for the twenty year intercensal period 1931-51, when there was an increase of 3,806,000, consisting of a natural increase of 3,051,000 (after subtracting 240,000 war deaths occurring abroad) and a net inward migration movement of 755,000. It is interesting to note that natural increase in the period 1951-61 was characterised by a progressive increase in the annual number of births from the mid-1950's onwards. The net gain by inward migration is largely attributable to the years 1958-61, culminating in a situation where net immigration exceeded natural increase for 1960–1. While the *Preliminary Report* does not say so, it seems fairly certain that West Indians must have played an important part in this recent immigration.

The density of population in England and Wales now stands at 790 persons per square mile, a figure exceeded in Europe only by that of the Netherlands (893 in 1958), while the density for Belgium is rather lower (769 in 1958). Japan has a density of 642, India of 313, China of 156, and the U.S.A. of 49.

Urban Population

The percentage of the population living in local government areas with urban status is calculated as 80.0 per cent, compared with 80.8 in 1951 and 82.4 in 1939. This reduction reflects the outward expansion

of towns into Rural Districts and the time-lag in extending municipal boundaries. The fact that a townward movement is still proceeding may be deduced from the fact that many Rural Districts with an agricultural bias showed a stationary or declining population.

Many of the cities and large towns with more than 100,000 inhabitants experienced a decline in population. For example, both Liverpool and Manchester had losses of over 40,000, and Newcastle upon Tyne, Salford and Sheffield each lost about 20,000. In the Midlands Derby, Leicester, Stoke-on-Trent, and Wolverhampton each lost about 10,000. On the eastern and northern fringes of the County of London there were losses of 10–15,000 from East Ham, Edmonton, Harrow, Leyton, Tottenham, Walthamstow, West Ham, and Willesden. The County of London itself declined by over 150,000, a loss of nearly 5 per cent, and the County of Middlesex by 39,000, a loss of nearly 2 per cent. Other substantial losses were experienced by Gateshead (12,000), Portsmouth (18,000) and Rhondda (11,000). Smaller declines of several thousands occurred at the Lancashire industrial towns of Blackburn, Bolton, Oldham, Preston, and St. Helens. In many instances, of course, these losses merely represent a shift of population to suburbs lying in neighbouring local government areas. In the case of Leicester, for instance, population increases in adjacent Urban and Rural Districts amply compensated for the decline of population in the city itself. Similarly the very slight growth at Nottingham of only 1 per cent must be viewed against the increases which occurred in four adjacent Urban Districts. The combined population of Nottingham and these four areas grew from 437,000 in 1951 to 461,000 in 1961, i.e. by 5.5 per cent, or rather more than the national average. Apart from this expansion in adjacent Urban Districts there was also suburban development in neighbouring Rural Districts.

Of the six large official conurbations in the country only the "West Midlands Conurbation" (i.e. Birmingham and the Black Country) grew at a rate (4.8 per cent) approaching the national average. Merseyside's population remained stationary, and the population of Greater London declined by 2 per cent. It should be pointed out that the boundaries of the official conurbations, like those of many individual towns, have become increasingly anachronistic.

Few of the cities and large towns with populations of over 100,000 grew by rates at or above the national average. One of the leading exceptions was Coventry, with an increase of 18 per cent (47,000). From being the twenty-third largest town in the country in 1931 it has now risen to be ninth, despite its considerable wartime destruction. In Essex, Hornchurch, Romford and Thurrock grew by 23, 30, and 39 per cent respectively, while in Bedfordshire Luton increased by 19 per cent. The following cities and large towns grew by between 5 and 9 per cent:— Bournemouth, Cardiff, Ipswich, Middlesbrough, Oxford, Reading, Southampton, Southend-on-Sea. All may be said to be prosperous industrial or residential towns with, presumably, municipal boundaries sufficiently generous to accommodate further population growth. The 1951 and 1961 populations of the official conurbations, the counties of London and Middlesex, and cities and large towns with more than 150,000 inhabitants are given in Table 1.

TABLE 1

URBAN POPULATION CHANGES, 1951–61

Official conurbations, wholly urban counties, and chief cities and towns.

	(thousands) 1951	1961
Conurbations:		
Greater London	8,348	8,172
S. E. Lancashire	2,423	2,427
West Midlands	2,237	2,344
West Yorkshire	1,693	1,703
Merseyside	1,386	1,386
Tyneside	836	852
Wholly urban counties:		
County of London	3,348	3,195
County of Middlesex	2,269	2,230
Chief cities and towns:		
Birmingham	1,113	1,106
Liverpool	791	747
Manchester	703	661
Leeds	506	511
Sheffield	513	494
Bristol	443	436
Nottingham	308	312
Coventry	258	305
Kingston upon Hull	299	303
Bradford	292	296
Leicester	285	273

	(thousands) 1951	1961
Newcastle upon Tyne	292	266
Stoke-on-Trent	275	266
Cardiff	244	256
Croydon	250	252
Portsmouth	234	215
Harrow	219	209
Southampton	190	205
Plymouth	208	204
Sunderland	182	190
Ealing	187	183
Ilford	185	178
Willesden	180	171
Swansea	161	167
Southend-on-Sea	152	165
Brighton	158	163
Bolton	167	161
Middlesbrough	147	157
West Ham	171	157
Salford	178	155
Bournemouth	145	154
Blackpool	147	152
Hendon	156	152
Wolverhampton	163	150

Source: General Register Office, *Census 1961 England and Wales, Preliminary Report* (H.M.S.O., 1961), Table 2, p. 14, and Table 5, p. 72.

More striking rates of growth were experienced by towns in the 50,000–100,000 range. Some of these are suburbs or very close neighbours of larger towns, and, indeed, it is the growth of such places which frequently must be set against the decline or stagnation of the larger towns which has already been noted. If we leave aside this category of suburban towns our list of towns in the 50,000–100,000 range growing at or above the national average includes the following:—(*a*) Towns a short distance from Greater London—Gravesend (15 per cent), Guildford (12), High Wycombe (24), Maidstone (11), Reigate (27), Rochester (14), Slough (21), St. Albans (14), and Woking (42) ; (*b*) The four New Towns near London which have now passed the 50,000 mark—Basildon (118), Crawley (405), Harlow (818), and Hemel Hempstead (149); (*c*) Provincial towns, with expanding industry in most instances—Bedford (19), Cambridge (17), Cheltenham (15), Colchester (13), Doncaster (5), Exeter (6), Lincoln (10), Peterborough (16), Port Talbot (14), Rugby (14), Scunthorpe (24), Stockton-on-Tees (9), Swindon (33), West Hartlepool (6), and Widnes (7) ; (*d*) Residential towns—Eastbourne (5), Harrogate (12), Poole (6), and Worthing (15).

Large increases also took place in some of the towns below 50,000, but again many of these are suburbs or satellites of larger towns. Excluding such places and applying a test of a 10 per cent increase corresponding to at least 5,000 persons we are left with a list in which towns within easy access of London are again an important category. These are Aylesbury (31 per cent), Basingstoke (53), Bishop's Stortford (43), Bletchley (56), Chelmsford (32), Egham (24), Leatherhead (31), Letchworth (26), Maidenhead (30), and the New Towns of Bracknell

(296), Hatfield (122), Stevenage (499), and Welwyn Garden City (86). Some of the former group are towns chosen under the Town Development Act for the reception of "overspill" from London. In the rest of the country the New Towns of Aycliffe (1937), Corby (117), Cwmbran (65) and Peterlee (4528) should be specially mentioned and also the midland towns of Hereford (24), Leamington Spa (19), and Stafford (19). A list of the official New Towns is given in Table 2.

TABLE 2

POPULATION OF THE NEW TOWNS, 1951–61

	1951	*1961*
Aycliffe (Durham)	594	12,101
Basildon (Essex)	24,661	53,707
Bracknell (Berks.)	5,143	20,380
Corby (Northants.)	16,743	35,880
Crawley (Sussex)	10,707	54,065
Cwmbran (Monmouth)	13,656	30,043
Harlow (Essex)	5,825	53,496
Hatfield (Herts.)	9,256	20,504
Hemel Hempstead (Herts.)	21,976	54,816
Peterlee (Durham)	298	13,792
Stevenage (Herts.)	7,311	42,422
Welwyn (Herts.)	18,804	34,944

Source: General Register Office, *Census 1961 England and Wales, Preliminary Report* (H.M.S.O., 1961), Table 2, p. 39.

Counties

From this consideration of changes in the urban population we now turn to the pattern presented by the county changes. These are shown in the accompanying map (Figure 1), where the proportionate and absolute changes are indicated for each administrative county (including associated county boroughs). It must be remembered, of course, that the counties differ greatly in area, population size, and economic structure. Frequently county boundaries violate major urban groupings, such as Greater London, Greater Manchester (South East Lancashire Conurbation), Merseyside, the West Midlands Conurbation, Tyneside, Greater Bristol, and Tees-side. In many instances the overall county percentage changes conceal marked local differences ; thus in Derbyshire the county gain of 6 per cent was the outcome of rural decline in the largely agricultural west of the county, decline or slow growth in the coal-mining districts of the east, and substantial increases in the north-east of the county close to Sheffield and in the Rural Districts encircling Derby in the south, which declined by 9,000.

In the accompanying map counties showing little change in population (increase or decrease of less than 2.5 per cent) are unshaded. Counties showing decreases greater than 2.5 per cent are dotted (London Merioneth, Montgomery, and Radnor). Counties increasing by between 2.5 and 5.0 per cent are shaded by broken lines, while counties increasing by more than 5 per cent (the national average approximately) are denoted by categories of line shading of increasing intensity according to rate of increase. Circles proportional in area to the absolute increases or decreases are superimposed on each county, except that increases or decreases of less than 2,500 are indicated merely by plus or minus signs.

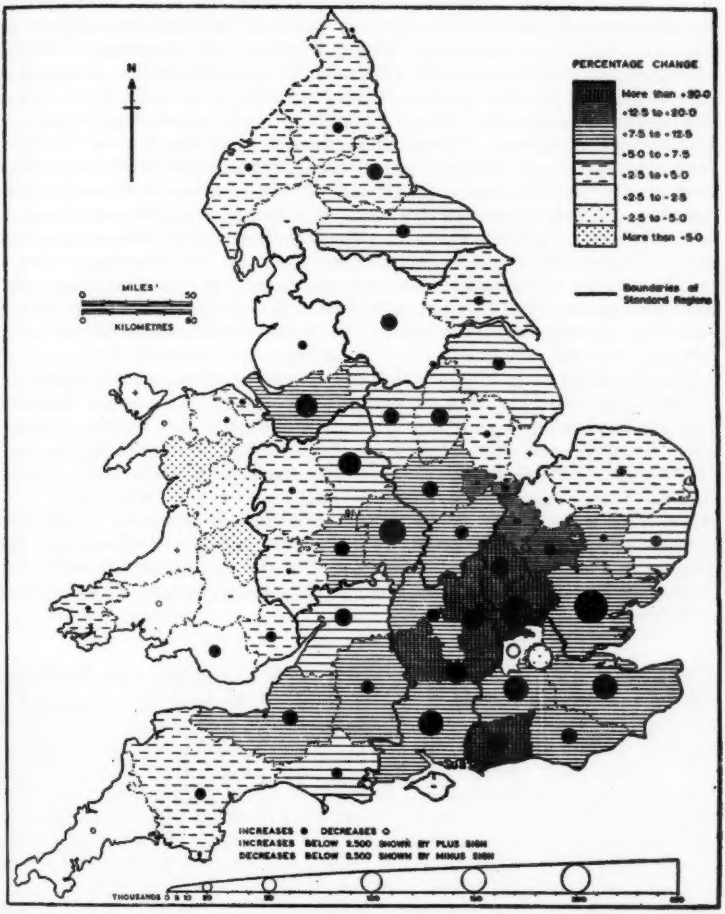

Figure 1

County population changes in England and Wales, 1951-61.

It will be seen that extending northwards from Dorset and Suffolk to the borders of Lancashire and Yorkshire there is a broad zone of counties where the growth of population was at or above the national average. Within this zone are the small built-up counties of London and Middlesex, which have lost population to adjacent counties, and the Isle of Wight, where a slight decline occurred. On the western, northern, and eastern flanks of the zone are groups of counties where population change was below the national average or where a decline took place. Such groups consist of Cornwall and Devon, Wales with Herefordshire and Shropshire, the northern counties of England lying beyond the Mersey and the Humber (with the exception, however, of the North Riding of Yorkshire) and Holland, the Isle of Ely, Kesteven, and Norfolk, forming a group surrounding the Wash.

The five highest percentage increases (Hertford 37, West Sussex 27, Buckingham 26, Berkshire 25, and Bedford 22) and five of the six highest numerical increases (Essex 242,000, Hertfordshire 222,000, Hampshire 139,000, Kent 137,000, and Surrey 131,000) all occurred in counties lying within approximately seventy-five miles of London. The decade witnessed a fall of 192,000 in the combined population of London and Middlesex. There was a decline in all but four of London's boroughs and in all of Middlesex's boroughs and urban districts, except Potter's Bar in the extreme north and a group of seven in the west of the county. Clearly this situation implies a large outward movement to neighbouring counties. Even in adjoining Essex and Surrey, however, population declines were recorded in some of the boroughs closest to the county of London, so that the areas of greatest expansion in these counties lay beyond a belt of older suburban settlement. In Kent the growth of population in the western part of the county near London was accompanied by a somewhat unexpected stationary or declining condition in the coastal area between Dungeness and Ramsgate. In Essex the chief areas of expansion were the New Towns of Basildon and Harlow and places along the north shore of the Thames estuary from Romford and Hornchurch in the west to Southend in the east. Chelmsford and Colchester also showed marked growth. All parts of Hertfordshire except the extreme north-east experienced high rates of growth ; these were especially high at the four New Towns of Hatfield, Hemel Hempstead, Stevenage, and Welwyn. In Buckinghamshire the increase was mainly in the southern half of the county and in Berkshire in the eastern two-thirds, that is, in the parts nearest to London in both counties.

Beyond these six counties which encircle London and Middlesex there were notable increases in Bedfordshire, Oxfordshire, Hampshire, and Sussex. Here most of the expansion occurred, respectively, in:—Bedford, Luton and Dunstable ; Oxford and south Oxfordshire ; north-east Hampshire, including Basingstoke, and the Bournemouth, Southampton, and Portsmouth districts in south Hampshire ; the New Town of Crawley, located in the north-east of West Sussex (accounting for about half the county's increase) and the chain of towns along the Sussex coast. The importance of population growth in the whole bloc of counties mentioned above—which, perhaps, we may call, for convenience, Metropolitan England—is indicated by the fact that the net increase here amounted to 1,119,000 during the decade, i.e. very nearly half the total national increase of 2,314,000.

To the north-east of these counties rates above the national average occurred in Huntingdonshire, Cambridgeshire, and West and East Suffolk. These were related to increases in the Huntingdon, Peterborough, Cambridge, and Ipswich-Felixstowe areas and also at Haverhill, which has an agreement to receive "overspill" from London. Defence establishments also exist in this part of the country. To the west of the Metropolitan group focal areas of increase were Poole-Swanage-Weymouth in Dorset ; Swindon (also taking London overspill) and the small industrial towns of north-west Wiltshire; and a zone stretching along the Severn lowlands from Tewkesbury (Gloucestershire) in the north to Bridgwater (Somerset) in the south and including the Cheltenham-Gloucester and Greater Bristol areas.

In the Midlands continued population growth occurred in the main industrial areas, leading to above average rates of increase in Staffordshire, Warwickshire and Worcestershire in the west Midlands and Derbyshire, Leicestershire, Northamptonshire, and Nottinghamshire in the east Midlands. In Warwickshire the striking growth of Coventry has already been referred to, but the growth of Birmingham's residential satellites of Solihull and Sutton Coldfield is also noteworthy. In Northamptonshire about half the county's increase was due to expansion of the New Town of Corby. In Lindsey, outside the main industrial areas of the midlands, there was a large increase at Scunthorpe and smaller increases in the Grimsby and Lincoln districts. High rates of increase occurred in the tiny counties of Rutland and the Soke of Peterborough, possibly related to an expansion of ironstone mining in the former, and certainly to an expansion of industry in and around Peterborough itself in the latter.

Cheshire appears as the county with the highest relative and absolute increase in the north of England. It must be remembered, however, that it includes expanding portions of Merseyside and Greater Manchester ("South east Lancashire Conurbation"), so that movement southwards across the Lancashire border should probably be held responsible for a large part of the county's increase. In both Lancashire and the West Riding of Yorkshire population losses from the leading cities and towns have already been noted. Areas of increase not offset by neighbouring losses occurred at resort and residential towns on the Lancashire coast, at Harrogate, and in the Doncaster area, where coal-mining and industry have been expanding.

In the East Riding, Durham, Cumberland, and Northumberland the rate of growth was low because local urban increases were not sufficiently high to counteract urban and rural declines in the rest of the county, including some mining districts. In the East Riding the Hull district experienced only moderate growth, while in Durham brisk expansion on Tees-side in the south, with its flourishing steel and chemical industries, was accompanied by little change in most other districts, including Tyneside and the coalfield, in both of which there were local declines. The New Towns of Aycliffe and Peterlee increased at an impressive rate, however, and the Sunderland district grew by about the national average. Across the Tyne, in Northumberland, Newcastle's large decline was offset by neighbouring local increases, but in the rest of the county there were rural declines. Rural decline also affected Cumberland, and of the towns only Whitehaven showed growth above the national average. Little change occurred in the population of Westmorland. The fairly high rate of growth in the North Riding is accounted for by large increases on Tees-side and to a lesser extent near York. The upward change in the North Riding is all the more remarkable when it is discovered that the Richmond Rural District suffered a decline of over 8,000, presumably because of a reduction of army personnel.

The total population increase in the northern counties amounted to only 306,000 (196,000 without Cheshire). This should be contrasted with the increase of well over one million in the Metropolitan group of counties. The former had 13,614,000 inhabitants in 1951 and the latter 15,046,000: the disparity in rate of growth is therefore obvious.

Wales, together with Herefordshire and Shropshire, constitutes a zone to the west of the expanding industrial Midlands where rates of increase were below the national average or where declines took place. Numerically and relatively the largest increases in Wales were in Denbigh and Flint in the north, where the growth of the resort towns and of Wrexham are noteworthy, and in Glamorgan, Monmouth, and Pembroke in the south. Increases occurred mainly in the coastal belt, especially in the Cardiff and Newport-Cwmbran areas, while in the valleys of the coalfield there were declines. The remaining Welsh counties, with their scattered population and emphasis on farming, showed declines or stagnation. In Herefordshire and Shropshire rural declines occurred in conjunction with substantial urban growth, especially at Hereford and Shrewsbury.

Finally we come to Cornwall and Devon and the counties near the Wash. Here, as in rural Wales and the Border counties, we may, perhaps, say that the provision of new employment opportunities has been insufficient to lead to a pronounced growth of population, especially in view of the considerable importance of agriculture. To a certain extent, however, it would seem that a decline of personnel in, or employed by, the Royal Navy, has played a part in the small loss of population from Cornwall and the only slight growth in Devon. Certain districts such as Newquay, Torbay, and the Exe valley nevertheless showed considerable growth. The counties near the Wash, with their small overall increases, also showed local urban growth. An expansion of population in the Norwich area should be noted. Part of the rural decline in these counties may possibly be due to changes in the numbers at Defence establishments since 1951.

The situation presented by the map and by the above analysis may scarcely be said to represent a surprise(1). Civil servants, local government officials and others have been well aware of a continuation in the 1950's of the "drift south" of the inter-war years from the "older" industrial and mining areas of the North of England and South Wales, and the census results merely confirm existing evidence. Retired persons have also continued to move to the south and to coastal areas in particular. While the continuation of the southward drift may be deplored, it can also be claimed that but for the apparatus of post-war planning the drift might well have been very much bigger. Inspection of the county figures of annual average rates of growth in the 1930's and the 1950's reveals that seven counties growing at rates much above the national average in the 1950's in fact experienced lower annual rates than in the 1930's, when the national population was growing rather less rapidly. These counties were Bedford, Essex, Kent, Oxford, Surrey, Warwick, and Worcester.

Regions

Finally we refer to Table 3, which presents a summary of the population changes according to the official Standard Regions. This shows the very high rates of growth experienced by the Eastern and Southern region and the low rate of growth in the London and South-eastern Region lying between them. The latter region contains London and Middlesex with their declining populations and only one New Town (Crawley). The two Midland Regions both show rates approaching 50 per cent above the national average. If the Eastern, Southern, and London

TABLE 3

REGIONAL POPULATION CHANGES, 1951–61

Area	*1961 Popn. (Thous.)*	*Increase 1951–61 (Thous.)*	*Per cent increase*	*Per cent average annual change*			*Net migration 1951–61 (Thous.)*
				Total	*By natural increase*	*By net migration*	
England & Wales	**46,072**	**2,314**	**5.3**	**+0.51**	**+0.44**	**+0.08**	**+352**
Northern ..	3,252	111	3.5	+0.35	+0.62	—0.27	— 86
E. & W. Ridings	4,168	71	1.7	+0.17	+0.40	—0.24	— 98
North Western..	6,568	122	1.9	+0.19	+0.37	—0.19	—124
North Midland..	3,634	256	7.6	+0.73	+0.55	+0.19	+ 65
Midland ..	4,754	332	7.5	+0.72	+0.59	+0.13	+ 61
Eastern ..	3,736	638	20.6	+1.88	+0.54	+1.34	+455
London & S.E...	11,093	187	1.7	+0.17	+0.33	—0.17	—183
Southern ..	2,819	378	15.5	+1.44	+0.54	+0.90	+237
South Western..	3,408	178	5.5	+0.54	+0.30	+0.24	+ 78
Wales	2,641	42	1.6	+0.16	+0.35	—0.19	— 49

Source: General Register Office, *Census 1961 England and Wales, Preliminary Report* (H.M.S.O., 1961), Table C, p. 7, and Table 2, p. 14.

and South-eastern Regions are combined their overall rate of growth (7.3 per cent) is, rather interestingly, slightly lower than that for either of the Midland Regions. In the rest of the country the South-western Region grew at a little over the national rate, followed by the Northern Region with 3.5 per cent, while the East and West Ridings, the North-western Region and Wales experienced low rates of 1.6 to 1.9 per cent.

The second part of the table shows the respective contributions made to the total regional percentage changes by natural increase and net migration, expressed as annual average rates. As regards natural increase there is a strong division between the Northern, Midland, North Midland, Eastern, and Southern Regions on the one hand, with above average rates of natural increase, and the remaining Regions on the other, with lower than average rates. These differences relate largely to differences in mortality, age structure, and the number of children per family. It will be seen that the rate for the Northern Region is more than twice that for the South-western Region.

The migration columns show losses from all three Regions constituting the north of England and also from Wales and from the London and South-eastern Region, with the Northern Region showing the greatest rate of loss. The high rate of natural increase in this Region puts it ahead of the East and West Ridings and the North-western Region as regards *total* change, however. The two Midland Regions and the Eastern, Southern and South-western Regions made migration gains. Grouping the Regions together we find that the North of England lost 308,000 persons, the Midlands gained 126,000, Metropolitan England with East Anglia gained 509,000, while the South-western Region gained 78,000, and Wales lost 49,000, giving a net gain to the country as a whole from the rest of the world of 356,000 (the table gives a total of 352,000).

The *Report* does not tell us anything about the migration movements themselves, for example the regional destinations of the outward migrants from the Northern Region or the origins of the inward migrants to the South-western Region. While some information on migration will be derived from the 10 per cent sample of persons who were asked to complete the fuller census questionnaire, it is, perhaps, rather unfortunate that county of birth was not asked for in the standard census questionnaire. No tabulation of the county of birth of all the inhabitants of each county will, therefore, be published in the forthcoming individual county reports, as was the case with the 1951 census. These county of birth tabulations provided the basis for an analysis of inter-county and inter-regional movements in the years preceding the 1951 census(2).

NOTES

(1.) R. H. OSBORNE, The "drift south" in Britain continues, *Tijdschrift voor economische en sociale geografie*, 51, No. 11 (Nov. 1960), 286–289.

(2.) IDEM, Internal migration in England and Wales, 1951, *Advancement of Science*, 48 (March 1956), 424–434.

EAST MIDLAND RECORD

BEVERCOTES COLLIERY

Bevercotes, which came into production in January, 1961, is the first colliery to be developed completely by the East Midlands Division of the National Coal Board, formed in 1947. It is expected to produce coal for a century, at a rate of about 1¼ million tons a year. When the surface buildings are completed the project will have cost about £10 million.

Preliminary borings made by the Wigan Coal Corporation, former owners of Manton Colliery, near Worksop, together with information derived from the working of Manton, Ollerton and Thoresby Collieries, indicated that coal reserves were large enough to justify the establishment of a new colliery. The site chosen for the shafts and surface installations is on the north side of the Maun-Meden valley, four and a half miles north-east of Ollerton and five miles south of East Retford. The nearest villages are Bevercotes to the south and Bothamsall to the west. In an area of 12 square miles centred on the colliery are estimated workable reserves in the three main seams of 107,253,000 tons, comprising 35,552,000 tons in the Top Hard, 26,746,000 in the Deep Soft and 44,955,000 tons in the Parkgate Seam.

Work on sinking the shafts began in 1952. They are about 2,850 feet deep, the topmost 800 feet being through permeable Permo-Triassic rocks in which water seepage presented problems that were overcome by the use of a "freezing" technique. The first shaft was completed in November, 1957, and the second in May, 1958. During 1960 a branch railway line was completed to the colliery from Ollerton where it connects with the Chesterfield to Lincoln line. This made commercial operation of the colliery possible in January, 1961, and the output will rise to its planned volume of 5,130 tons a day in the second year of working. The Parkgate seam is the first to be worked, and is expected to yield for 30 years.

When Bevercotes Colliery is in full production it will probably employ nearly 1,900 men, and for this large labour force many new houses will be needed. To accommodate the families of workers at other recently established collieries like Calverton, Ollerton and Thoresby large housing estates were built adjoining the existing villages. In the case of Bevercotes a different policy is being adopted. The planning authorities believe that a new mining village at Bevercotes would be too small to support the range of social amenities and services regarded as normal to modern urban life, and it is therefore proposed to distribute the new houses among existing settlements. Over 700 of the 1,150 houses needed will be built at the colliery village of New Ollerton, and the remainder at various other places like Bothamsall, Elkesley, Tuxford and East Retford. The concentration on New Ollerton, where the new Miners' Welfare facilities for Bevercotes will be provided, reflects the fact that Ollerton, near an important focus of roads, has been chosen as a main urban centre for this district of growing importance, and its population (Ollerton and Boughton parishes) is expected to exceed 10,000 by 1971.

These arrangements have not been well received by representatives of the mining industry. Each colliery generates a high degree of loyalty which expresses itself in social activities, and the dispersal of Bevercotes miners, and the absorpton of many in New Ollerton must militate against the development of this particular form of community feeling and social activity.

C.M.L.

The Horncastle and Bain Valley Flood

On 7 October 1960 a severe flash flood caused considerable damage in Horncastle. It was the result of a very rapid rise of the left bank tributaries of the River Bain, caused by exceptionally heavy rainfall over a short period. Rain began to fall in the Horncastle area about 10.30 a.m. on 7 October. By 11.00 a.m. it was torrential, and it continued thus with little change until 5.00 to 5.30 p.m. It appears to have been

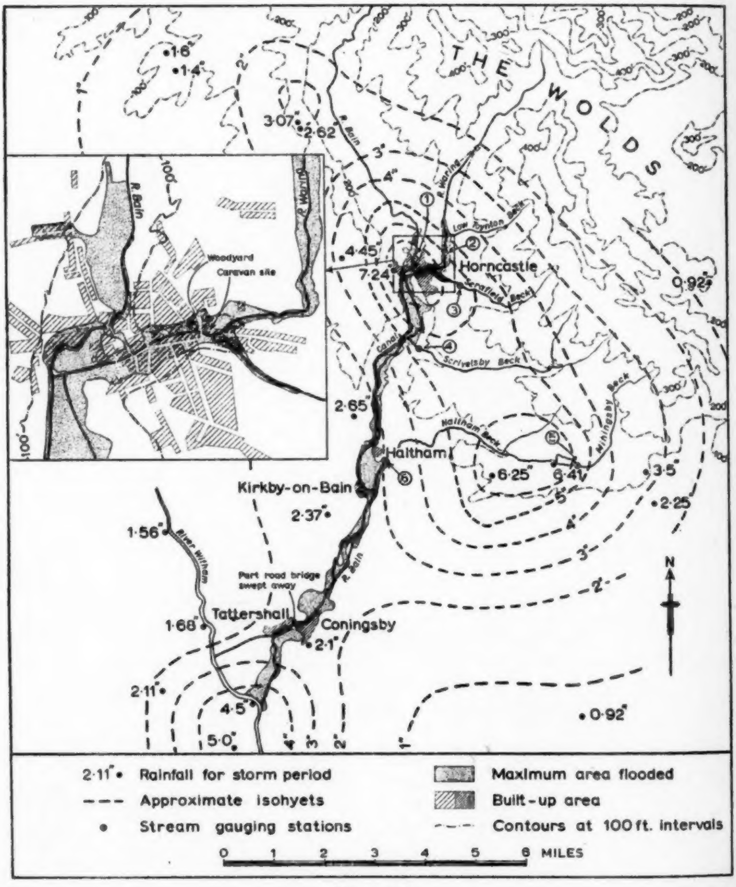

Figure 1

Flooded area and approximate isohyets for 7 October 1960 in the Horncastle district. Inset shows area flooded in Horncastle.

produced by a succession of at least three separate thunderstorms, from which a total of 7.24 inches of rain in six hours was measured at Horncastle itself. At Revesby Reservoir, on Haltham Beck, 6.41 inches fell in three hours between 1.30 and 4.30 p.m. The distribution of flooding and the day's rainfall at a number of stations in the area are shown in Figure 1. The isohyets on this map must be regarded as approximate.

The rainfall records show that the heaviest rain fell over central Horncastle and the area to the east and south-east, although there was a secondary area of high rainfall around the confluence of the Bain with the River Witham below Coningsby. Consequently the River Waring and its tributary the Scrafield Beck, and the Scrivelsby and Haltham Becks each brought a very heavy flow of water into the Bain valley. At Hemingby, three miles above Horncastle, the Bain was running only half-full, and was discharging about 430 cusecs at the maximum where it enters Horncastle, but the Waring and its tributary at their junction were discharging up to 1745 cusecs, while near their junctions with the Bain the Scrivelsby Beck and Haltham Beck were contributing about 1425 and 2798 cusecs respectively (Table 1). The last figure represents a greater flow than that of the River Trent past Trent Bridge in a normal dry period, and may be compared with the 2373 cusecs which is the normal discharge of the River Thames at Teddington. But since both the Scrivelsby and Haltham Becks flow through open country they caused no damage on the scale of that in Horncastle, although they contributed substantially to the flooding of the Bain valley. The very large flow of the Waring tributary per 1000 acres of its catchment, and the comparatively small flow of the Miningsby Beck (the upper part of the Haltham Beck) as shown in Table 1, have been taken into account in drawing the isohyets over their catchment areas.

TABLE 1

	Stream	*Total catchment area (acres)*	*Catchment area to gauges*	*Approx. flow (cusecs)*	*Flow per 1000 acres (cusecs)*
1.	Upper Bain	30,726	30,726	430	14.2
2.	Waring	5,506	5,076	800	158
3.	Scrafield Beck	2,114	1,982	945	476
4.	Scrivelsby Beck	3,338	3,294	1,425	433
5.	Miningsby Beck	2,000	1,786	208	116
6.	Haltham Beck	5,948	5,678	2,798	492

The Waring is joined by its tributary, the Scrafield Beck, in the eastern part of Horncastle, and its channel in the town is less than 20 feet wide, being constricted between road and buildings. The Waring then becomes the old Horncastle Canal, and joins the Bain west of the town, where water is able to escape southwards along both the canal and the Bain itself. Silting has been a problem, especially in the canalised section of the Waring through the town, where the bed is sometimes within three feet of the level of the roadway. The canal has been disused for nearly a century, but in recent years it has been cleaned and dredged as an auxiliary channel for Bain water.

On this occasion the Waring, the Bain and the old canal all proved inadequate to carry away the great volume of water running down into Horncastle. At noon the Waring began to overflow on to the road along its bank. This is not unusual; but from about 12.30 p.m. much heavier

flooding began to spread, and by 1.00 to 2.00 p.m. the great quantity of water brought down by the Waring and its tributary, and by the roads sloping down to the river, was being discharged into the town itself. Water spread quickly over the low-lying part of Horncastle, flooding part of the shopping centre, inundating many premises to a depth of up to 6 feet, and reaching a depth of 8 feet in some areas. In some parts of the town the flood water spread with remarkable rapidity—almost like a wave. At the time of maximum flow caravans were moved from a site near the confluence of the Waring and its tributary, timber from a wood yard just above bank level was swept downstream together with a car and a van, and the debris formed temporary dams which increased the depth of the flood water and played a part in damaging buildings and carrying away two foot bridges.

The Bain above Horncastle was less seriously affected and a wide area of meadow land adjoining it on the west side safely took most of its surplus water. That flooding occurred at all from the Bain above its confluence with the Waring was probably due to the ponding back of water by the great volume arriving along the Waring at the right-angled junction of the two rivers, where discharge was further impeded by the remains of staunch doors. But below Horncastle, where the Bain valley received the floods of the other left bank tributaries when already swollen by the Waring's water, the banks were overtopped in a number of places, several minor breaches were opened, and there was extensive flooding along the valley from Horncastle down to the Bain-Witham confluence. The flood waters were contained on the west side, and further downstream on the east, by the line of the old canal, which stands higher than the river. The area of flooding was mainly quite narrow, though widening to half a mile between Haltham and Kirkby-on-Bain, and again above Coningsby. The village of Kirkby-on-Bain was seriously flooded. Few roads cross the valley, but part of the bridge on the A153 road between Tattershall and Coningsby was washed away.

Apart from occasional showers rain had ceased by 5.00 to 5.30 p.m.; most of the streets of Horncastle were clear of water by 8.00 p.m.; and by the next morning the River Waring was well below bank-full. Elsewhere, too, the floods subsided rapidly.

This was not the first time that intense local rainfall had caused flooding at Horncastle. Notable previous floods were those of 31 December 1900, and 29 May 1920, the latter being caused by a "cloud-burst" on the high Wolds near Stenigot, with 6.3 inches of rain measured at Horncastle. The 1960 flood was caused by very slowly moving thunderstorms developing in a somewhat stagnant synoptic situation. Maritime air was moving slowly north-westwards across Lincolnshire in the circulation of a filling Atlantic Low centred over southern England, and was flowing beneath a weak, east-moving, moist upper current which also had cyclonic curvature in an upper trough. The tropopause must have been exceptionally high for the time of year, for it was reported that a pilot from Cranwell found the cumulonimbus cloud still towering above him at a height of 40,000 feet over Horncastle.

There is a local belief that storms tend to lodge in the Bain valley against the western edge of the Wolds, and this higher ground may well serve to set off thunderstorm development in unstable conditions. On

this particular occasion the general location of this group of heavy storms could doubtless be explained by the general synoptic conditions over the country, but their location on the west side of the Wolds, and their persistence there for many hours was almost certainly a consequence of the operation of some local factor favouring thunderstorm development.

On both the earlier occasions mentioned above the river that flooded was the Bain, but in 1960 the flooding of Horncastle was due to the inability of the Waring to carry away the great volume of water running off its catchment area, and the flooding of the Bain valley was due to the inability of the Bain to contain the great discharge of its three left bank tributaries at and south of Horncastle.

Grateful acknowledgement is made to the Engineer of the Lincolnshire River Board for the data on rainfall and stream discharge, and to the Clerk of Horncastle U.D.C. for other information.

D.N.R. and F.A.B.

THE TRAFFIC PROBLEM IN NOTTINGHAM

Traffic problems in British cities have become progressively more acute in recent years, largely as a result of the effect of the growing numbers of private cars on outmoded road and street systems. A recent report by the Nottingham Junior Chamber of Commerce gives an interesting summary of the leading features of Nottingham's traffic problem and suggests certain remedies, some conventional and others of a more radical nature. The report estimates that at present 50,000 motor vehicles habitually use the roads of the city, and suggests that in twenty years' time provision must be made for at least three times this number. A primary need exists, therefore, for an "overall city traffic plan" for the future, preceded by a detailed official survey of the present problem.

Four sub-committees made a study of traffic flow, parking, pedestrians and safety, and municipal transport respectively. As regards traffic flow the report considers that ease of movement is a very important consideration "if the city is to prosper as an economic unit and social centre." Amongst the recommendations are: flyover systems at busy crossings, the staggering of working hours, and a deliberate use of the inner and outer ring roads, already partially in existence, to deflect traffic from the city centre. Tentative suggestions are put forward for a municipal van delivery service for small traders whose own vehicles cannot be fully utilised, and a monorail service to the suburbs. Needless to say, restrictions on vehicle ownership and on free entry to the city are not considered to be desirable or feasible except as a last resort.

The problem of parking receives considerable attention. "Off-street" parking places are now twice at numerous as in 1949, "but even then provision was inadequate, and since then car usage has grown at a faster rate than was anticipated." The city's "Rainbow Plan" is welcomed by the Report, but it is pointed out that, by reducing the number of permitted "on-street" parking places, the immediate effect may be to worsen the problem unless additional parking facilities are quickly provided. Speedy action regarding the provision of more multi-storey car parks is therefore called for (although one is already in

existence and another is planned). The question of the financing of such facilities should also be looked into. The "styling" of cars is criticised as being "too prodigal of road space in relation to passengers carried". The report also points to the "fundamental absurdity" of motor vehicles standing idle, "not moving but parked awaiting the requirement to move", and suggests that "it may be more valuable to envisage an expansion of the car-hire service rather than an increase in individual car ownership." (This is a solution *à la* Khrushchev, readers will note).

In 1960 thirty people were killed and about two thousand injured on Nottingham streets. As a measure for increasing road safety for pedestrians the report stresses the greatest possible separation of vehicles and pedestrians, e.g., by the greater use of tubular steel railings and the building of overhead or underground passages at crossing places. More controversial suggestions include blood tests for drunken driving and the scaling of motor insurance rates in the light of the individual driver's record.

In the section on municipal transport facilities the report draws attention to the declining use of the city's passenger transport system (motor-buses and trolley-buses) as a result of increasing private car ownership. The number of passengers carried has been falling every year since the peak of 174 millions was reached in 1952; the present figure is about 140 millions. The evening rush-hour problem remains a serious one, however, 43,000 people using city buses between 5.30 and 6.30 p.m. The resulting long queues and uncomfortably crowded travelling conditions might be reduced by a staggering of working hours. The increasing use of private cars at the rush-hour worsens the general traffic problem, since a fully-loaded double-decker bus takes up three and a half square feet of road space per passenger, while a private car containing one person may require seventy square feet.

To halt the loss of passengers and to re-attract the private motorist the City Transport Department should introduce certain changes and carry out a deliberate publicity campaign. A standard fare of 3½d. should apply irrespective of distance travelled, while drivers and conductors should receive an "incentive bonus" based on the number of tickets issued and should receive higher "loyalty pay" than they do at present. More bus shelters for passengers are called for and better designed buses are also necessary. Cheaper fares might be introduced at the "off-peak" periods of the day. Circular suburban routes avoiding the city centre are also needed. With the progressive completion of the inner ring road buses should be made to terminate here (as already suggested by the former City Engineer) and a free bus service should circulate along it, possibly also calling at the city centre.

For the distant future the report suggests an investigation into the practicability of a monorail system connecting the inner ring road of the city with outlying suburban residential areas. Five lines are suggested: to Arnold, Basford and Bestwood, Carlton and Gedling, Beeston, and West Bridgford and Clifton.

R.H.O.

Proposed Electricity Generating Station at Holme Pierrepont

In the last number (No. 14) of this journal reference was made by Mr. E. M. Rawstron, in an article on Trentside power stations, to applications by the Central Electricity Generating Board to build large power stations at West Burton and Holme Pierrepont in Nottinghamshire. Consent by the Minister of Power to the West Burton project was given in February, 1961, and the station should begin to produce electricity in 1965 and be fully commissioned by the end of 1967. It was anticipated in December 1960 that the outcome of the Public Enquiry into the Holme Pierrepont proposal would have been available for comment in this issue, but no decision by the Minister of Power has yet been announced. It may be of interest, however, to summarise briefly the proposal of the Generating Board, and the opposing arguments of the objectors, who included all the Local Authorities likely to be affected, and whose vigorous opposition to the proposal prolonged the Enquiry into late January, 1961.

The Board plans to build a power station of 2000 MW. capacity—the same size as that which will be built at West Burton—on a site of about 500 acres alongside the right bank of the Trent between West Bridgford and Radcliffe-on-Trent (Fig. 1). There is a strong likelihood that, if built, this would be joined on the same site soon afterwards by a second station of the same size. Such a 4000 MW. installation, costing about £150 million, would be far larger than that at any generating site yet known in this country or in Europe. It would have two boiler houses, each about 200 feet high; four chimneys, each of 650 feet; and 16 cooling towers, each about 375 feet high. Its annual coal consumption would approach 10 million tons a year, about the same quantity as all the electricity plants in Britain together consumed in the early 1930's, and equivalent to half the total output of the South Wales coalfield. A coal supply of up to 35,000 tons a day would require about 40 coal trains with some 1,400 wagons daily, that is, 80 trains in and out. In addition to the plant mentioned, therefore, extensive railway sidings would be needed, with perhaps 12 or 15 locomotives operating on the site, and about 100 acres would be required for a reserve coal store of about one million tons. The objectors have contended that because of the limited capacity of disused gravel workings nearby, where ash could be dumped, great quantities of dust would also have to be moved from the site eventually by rail or road. The coal traffic alone would represent 8 to 9 per cent. of the total volume of rail traffic in coal throughout the British Isles in 1958, and since the greater part of the traffic would be from the Nottinghamshire coalfield across the river, Radcliffe-on-Trent, with the sidings nearby, would be completely dominated by the railway operations. Further, it is logical to suppose that if a breeze block industry using part of the coarse ash were established on or near the site, it would be difficult to refuse planning permission for other industries in the vicinity, and the whole area between West Bridgford and Radcliffe would become an industrialised zone where there is now open country, so far untouched by industry except for gravel workings.

The probable economic advantages of the Holme Pierrepont site to the Generating Board are discussed in Mr. Rawstron's article. Apart from the general advantages of location possessed by sites along the middle Trent valley, it may be supposed that an additional claim of the Holme Pierrepont site is that a railway here crosses the Trent to link

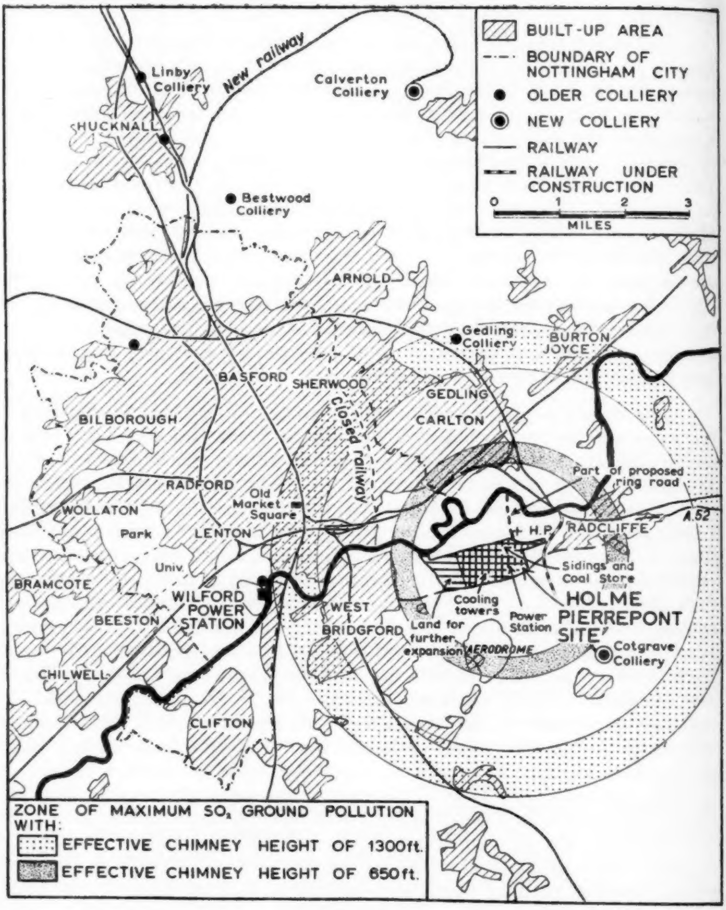

Figure 1

the site with the main coalfield area lying north of the river. Another railway is in course of construction from the new Cotgrave Colliery, the only mine south of the river, whose output the power station would be well placed to absorb. However, the objectors expressed doubts as to whether the existing railways could handle the great quantities of coal needed without disorganising other traffic, and noted that it was unlikely that the disused line across the city using the closed Mapperley tunnel could be re-opened.

The objections to the scheme fall into three main groups: objections on planning and general amenity grounds; those relating to risks of pollution; and those relating to economic considerations. The last group includes doubts by the objectors whether the calculations by the Generating Board of the margin of economic advantage possessed by the Holme Pierrepont site over others have been soundly based, their

suspicions being heightened by the fact that the data used include confidential financial arrangements with the Transport Commission which could not be revealed.

The local planning authorities object on principle to the building of this enormous industrial plant within the scheduled green belt, holding that to do so would, by implication, make nonsense of all planning proposals for the area unless it could be clearly shown that no alternative were possible, and they did not believe this to be the case. In addition, one practical objection is that a power station at Holme Pierrepont would require a complete realignment of the projected ring road on the east side of Nottingham. Further, to cite only two of the settlements likely to be affected by the development, it has been authoritatively estimated that the power station would result immediately in a capital depreciation of about £3 million in the value of property in West Bridgford and Radcliffe, both highly residential and substantially modern settlements.

These two places together contain little more than 30,000 people, but there is a population of some 425,000 within five miles of the site. The possible exposure of this large population to health risks was a matter of much concern to the objectors, despite assurances from the Board's emission expert that the effect of pollution from the proposed power station would be negligible. It was asserted on behalf of the Board that in consideration of contours, "population in the vicinity", wind strength and direction, fogs, existing levels of pollution and "regard to other power stations", Holme Pierrepont was more favourable from the emission point of view than any alternative site suggested by the County Council except Cottam. The inferior sites included Ragnall or Woodcoates (north of High Marnham), Sturton-le-Steeple (near West Burton) and Upton (Averham) near Staythorpe. This conclusion was challenged by Mr. F. A. Barnes, for the objectors, who maintained that in respect of each of the criteria mentioned Holme Pierrepont must be at least as unfavourable a site as any of the others, and clearly the least favourable in some respects, and especially as regards size of local population and existing level of pollution.

It was pointed out that the high efficiency of modern dust-arresting devices must be set against the enormous dust output of this great station, and it was suggested that despite the great height of the proposed chimneys the intensity of pollution in the zone of maximum ground pollution would probably be substantially higher than that from existing stations such as Staythorpe. The Board maintained that such pollution would, in fact, be negligible, but the objectors quoted recent medical findings on the dangers of small increases in an already considerable level of urban air pollution to sufferers from cardio-respiratory diseases, the incidence of which is deplorably high in this country. The zone of maximum ground pollution from Holme Pierrepont would extend as an arcuate band across the centre of the city of Nottingham, and across West Bridgford with winds from between north-east and south (Fig. 1), and it was noted that moist, stable airstreams from these directions are not infrequent; that the annual output of sulphur dioxide gas from a 4000 MW. station, none of which would be extracted, would be of the order of 160,000 to 180,000 tons (10 or 12 times that from the several existing North Wilford stations); and that in moist air this would rapidly

take the form of sulphuric acid droplets. These considerations gave rise to fears of serious damage to the health, comfort and property of the people of Nottingham and its environs, especially in view of the possibility of unpredictable short-term levels of pollution many times the average.

It became clear that the crux of the Enquiry's problem was not *whether* this proposed power station should be built on Trentside, but *where* it should be built—a complex problem in physical and social as well as economic geography. The Generating Board held the view that the various objections to the Holme Pierrepont site were insufficient to outweigh its economic advantages. The objectors, for their part, urged that some predicted advantages of the site were dubious, and others unascertainable because they were based on confidential data that could not be made available to independent experts. It was also held that in a modern society professing concern for the health and amenities of the public at large, as expressed in the establishment of smokeless zones and green belts, considerations of general public good should take precedence over public advantage in a narrow sector, namely a marginal economic advantage in the national cost of electricity generation.

F.A.B.

After this Note had gone to the printer it was announced in the House of Commons (3 July 1961) that the Minister of Power had decided not to grant permission to the Central Electricity Generating Board to build the proposed power station at Holme Pierrepont. The Ministry's letter announcing the decision set out briefly the case of the Board and that of the objectors, the observations of the Inspectors (the Chief Engineering Inspector of the Ministry and a Senior Inspector of the Ministry of Housing and Local Government) and their recommendations. The Generating Board noted that the particular advantages of the Holme Pierrepont site were: an ideal situation for coal supply at a cheaper rate than at the other Trentside sites considered ; admirable foundations ; a site unlikely to be flooded ; a good mains water supply ; good access roads; only three short transmission lines needed to carry the output to the national grid ; some space for fly ash disposal nearby ; a second station could be built on the same site. They expected no marked increase in atmospheric pollution at ground level ; would ensure a high standard of design and landscape treatment ; and set the loss of 525 acres of agricultural land against the production of £25 million worth of electricity a year for the nation. The objectors' full case included, in addition to the points mentioned in the Note above, the impairment of the unspoiled village of Holme Pierrepont ; sterilisation of a large deposit of good gravel in an area where it is much needed ; serious interference with the present drainage system ; and introduction of further road congestion by increasing heavy road traffic near the city and interfering with traffic flow by the closure of level crossing gates for longer periods. Special stress was laid on the fact that the station, which would extend the built up area round Nottingham, seriously impair the important amenity of the river side, and eliminate the wedge of open country stretching towards the centre of the city, did not fall into any of the exceptional classes of building which might in special circumstances be allowed in a green belt.

The Chief Engineering Inspector, while noting the urgent need for good power station sites, which are scarce, and the particularly good qualities of that at Holme Pierrepont, agreed that the close proximity to Nottingham was a serious drawback because of the additional traffic congestion it would cause ; thought it better from the pollution point of view to site it, if possible, away from such a large residential area ; and was not inclined to stress too greatly the Board's contention that electricity generation at Holme Pierrepont would be £600,000 a year cheaper than at any of the alternative sites suggested. The Planning Inspector, though noting the good road access, commented on the disruption of the valuable wedge of open country, the impairment of Trentside as a place of public resort, the likely noise problem, and the

special difficulties of the Hoveringham Gravel Company. He considered that Ratcliffe-upon-Soar was the most suitable of the alternative sites mentioned during the Inquiry, and those at Cottam and West Burton the least suitable.

The Inspectors therefore recommended that the application of the Board be refused because all the alternative sites were capable of development without the disadvantages attending that proposed at Holme Pierrepont, which would seriously impair the value of the wedge of open country between West Bridgford and Radcliffe-on-Trent as part of the proposed Nottinghamshire green belt, and promote a large increase in road and rail traffic in an urban area where there is already a serious traffic problem.

It now seems likely that the proposed site for a power station at Ratcliffe-upon-Soar will receive urgent consideration.

Underground Ironstone Mining

The output of ore from the Jurassic and Cretaceous ironstone fields of the East Midlands continues to expand. In 1960, out of the total home production of 17 million tons, more than 15 million tons came from these sources. In this connection, it should be noted that production from the Cleveland district of Yorkshire is now less than half a million tons compared with over two millions before the war. Thus the expansion of output planned for the 1960s is destined to come almost entirely from the East Midlands.

At present about 80 per cent. of all the iron ore raised in this country is extracted by opencast methods, including by far the greater part of that produced in the East Midlands. As these shallow-lying ores become exhausted, the general eastward dip of the beds will increasingly necessitate underground working. The latter method is more costly, however, for it requires a larger labour force including a higher proportion of skilled men, and does not permit of the total extraction of the ironstone. For the continuance of opencast operations the critical factor is the amount of overburden which must be removed, but progressive improvement in opencast techniques and equipment is also playing its part. In mid-Northamptonshire (Northampton Sands ironstone) as for example in the Corby district, ironstone lying more than 40 feet below the surface was considered in 1950 to be near the limit of accessibility; but to-day enormous dragline excavators can remove over 100 feet of overburden. Soon even more powerful machinery will be installed in this area and also at Colsterworth near Grantham.

While opencast extraction will continue for many years, underground workings are likely to be developed on a considerable scale in the near future. Already several mines are in operation. These are of the drift or adit type, the entrance to which is located near the edge of the deposits to be worked, whereas in the case of a vertical shaft the latter is placed centrally. The drift gradient is governed both by the dip of the strata and by the methods of haulage to be installed. Naturally for locomotives a much gentler gradient is required than that for belt conveyors and rope haulage. Similarly the dimensions of the drift are governed as much by the size of extraction and transport equipment as by ventilation requirements.

At Thistleton, near Oakham, a mine was opened in 1956 to work ore occurring at 200 feet below the surface. Although production was delayed for a time because of unexpected physical difficulties, output

has now begun and should eventually approach a million tons a year. Another mine at Easton, near Grantham, is now producing at the rate of 150 thousand tons a year but is expected to exceed this amount later on. It is in North Lincolnshire (Frodingham Ironstone) however that underground methods are furthest advanced. To serve their Appleby-Frodingham works at Scunthorpe, the United Steel Co. have for some years operated two mines, at Santon and Dragonby, to the east and north of the town respectively. Santon was first opened in 1938 and Dragonby, much the larger of the two, in 1950. Together they are now producing well over a million tons a year. These are highly mechanised adit workings, using electric drilling machines, mechanical loaders and conveyor belts, the last-named carrying the ore to railway wagons at the mine entrance for direct dispatch to the works. Even here the use of the most modern equipment has resulted in increasing productivity, for in the past three or four years the weekly output at Dragonby has risen by 50 per cent., *i.e.*, from 11,000 tons to 16,500 tons, with only a small increase in the number of men employed. At Dragonby, quite apart from branch workings from the main adit, the Frodingham Ironstone, about 20 feet in thickness, will be exploited for at least 2½ miles eastward from the entrance, *i.e.*, to the line of the Ermine Street, where it is about 300 feet below the surface.

Another of the Scunthorpe firms, John Lysaght and Co., is now using underground methods in working the Claxby Ironstone (Lower Cretaceous) from the Wolds escarpment in Lincolnshire. The outcrop of this ironstone can be traced for a few miles along the face of the scarp southwards from Caistor. About a mile south of the village of Nettleton it is 14-15 feet in thickness and has an iron content varying from 28 to 33 per cent. In addition to opencast extraction, both on the scarp face and on the dip slope overlooking the valley of the Nettleton Brook, underground mining now enables a much greater output to be maintained, besides providing a means of exploiting the deeper reserves lying beyond the Nettleton Brook. In fact the adit reaches as far as the line of the ancient High Street connecting Caistor and Horncastle. From the working face, the ore is conveyed by a mineral line to the mine entrance and thence carried by motor trucks to the railway at Holton-le-Moor, some fifteen miles from Scunthorpe.

If the output of home-produced ore is to be maintained, an increasing development of underground working will become essential. A recent survey of unproved reserves in the Northampton Sands formation lying north of the River Welland has not only confirmed the existence of some 175 million tons of workable ore but has shown that nearly half of this amount will have to be won by underground methods.

K.C.E.

Gill Memorial Award

Congratulations are extended to Dr. Cuchlaine A. M. King, Lecturer in Geography in the University of Nottingham, and a frequent contributor to this journal, on the presentation to her of the Gill Memorial Award of the Royal Geographical Society. The Award was made in recognition of Dr. King's important contributions in the fields of glaciological and coastal research, and was presented to her by H.R.H. Princess Marina, Duchess of Kent, at the Annual Meeting of the Royal Geographical Society held at their headquarters in London on 19 June, 1961.

Corrections

In the article on the Churnet Valley in No. 14 (Dec. 1960) of the *East Midland Geographer* a sentence occurs on page 36, line 6, beginning "He suggested . . ." which appears to attribute to Dr. E. M. Yates the view that the Keele Surface is an exhumed sub-Triassic surface. It should be pointed out that, on the contrary, Dr. Yates regards the Keele Surface as an erosion surface of Tertiary age (*E.M.G.* No. 5, June 1956, p. 19). The sentence in question should be amended to read "He suggested that this direction was superimposed from a covering stratum sloping in this direction."

In the article entitled "Industry and Transport in Derby" by B. J. Turton, in *E.M.G.* No. 14 (Dec. 1960) on page 3, third line from the bottom ; for Figure 1 read Figure 2.

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